*भारतीय मानक*
***Indian Standard***

**IS 883 : 2016**
**(Reaffirmed 2021)**

# निर्माण कार्यों में संरचनात्मक इमारती लकड़ी के डिजाइन — रीति संहिता

*( पाँचवा पुनरीक्षण )*

# Design of Structural Timber in Buildings — Code of Practice

*( Fifth Revision )*

ICS 91.010.30; 13.220.50; 91.080.20



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FOREWORD

This Indian Standard (Fifth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Building Construction Practices Sectional Committee had been approved by the Civil Engineering Division Council.

This standard was first published as Code of practice for use of structural timber in building (material, grading and design) in 1957 and was first revised in 1961. In the second revision in 1966, where clauses relating to specification and grouping of structural timber were deleted and these aspects were covered in detail in a separate standard, namely IS 3629 : 1966 'Specification for structural timber in building, which was subsequently revised in 1986. The third revision of this standard took place in 1970 and the fourth revision in 1994. The different species of timber available in the country which have been tested so far and found suitable for construction purposes have been classified into three main groups based on modulus of elasticity and modulus of rupture. Safe working stresses of recommended species and their relevant pertinent data given in this standard have largely been derived from publications of Forest Research Institute, Dehradun.

The standard has been updated with incorporation of brief inputs on fastening devices, design of tension members, timber roof trusses and purlin; and a table on nail shafts. In the formulation of this standard due weightage has been given to international coordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

This standard is one of the two Indian Standards on structural timber in building. Further, IS 14616 : 2009 'Laminated veneer lumber – Specification' is also being used for structural applications such as beams, rafters, stringers, etc.

The composition of the Committee responsible for the formulation of this standard is given at Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Indian Standard*

# DESIGN OF STRUCTURAL TIMBER IN BUILDINGS — CODE OF PRACTICE

*( Fifth Revision )*

## 1 SCOPE

**1.1** This standard covers the general principles involved in the design of structural timber in buildings.

**1.2** The following aspects are not covered in this standard:

a) Timber pile foundations [*see* IS 2911(Part 2)];

b) Structural use of plywood;

c) Design of structural timber joints and fastenings (*see* IS 2366 and IS 11096);

d) Lamella arch roofing;

e) Timber-concrete composite construction; and

f) Wooden pole structures.

## 2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A.

## 3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 707, IS 3629 and the following shall apply.

**3.1 Box Column —** A column formed of four members having a hollow core. Members are joined with one another forming a box and provided with solid block at ends and intermediate points.

**3.2 Fundamental or Ultimate Stress** — The stress which is determined on small clear specimen of timber, in accordance with standard practice and does not take into account the effect of naturally occurring characteristics and other factors.

**3.3 Permissible Stress —** A stress obtained after applying factor of safety to the ultimate stress.

**3.4 Purlin —** A roof member directly supporting the roof covering or rafter and roof battens.

**3.5 Solid Column —** The solid columns are formed of any section having solid core throughout.

**3.6 Spaced Column** — The **s**paced columns are formed of two or more members jointed at their ends and intermediate points by block pieces

**3.7 Working Stress —** The **s**tress obtained after applying necessary adjustment factors (according to the particular design) to the permissible stress.

**3.8 Beam, Built-Up-Laminated** — A beam made by joining layers of timber together with mechanical fastenings, so that the grains of all layers are essentially parallel.

**3.9 Beam, Glued-Laminated** — A beam made by bonding layers of veneers or timber with an adhesive, so that grain of all laminations is essentially parallel.

**3.10 Diaphragm, Structural** — A structural element of large extent placed in a building as a wall, or roof, and made use of to resist horizontal forces such as wind or earthquakes, acting parallel to its own plane.

**3.11 Duration of Load** — A period during which a member or a complete structure is stressed as a consequence of the loads applied.

**3.12 Edge Distance** — The distance measured perpendicular to grain from the centre of the connector to the edge of the member.

**3.13 End Distance** — The distance measured parallel to grain of the member from the centre of the connector to the closest end of timber.

**3.14 Finger Joint** — The joint produced by connecting timber members end-to-end by cutting profiles (tapered projections) in the form of V-shaped grooves to the ends of timber planks or scantlings to be joined, gluing the interfaces and then mating the two ends together under pressure.

**3.15 Fundamental or Ultimate Stress** — The stress which is determined on small clear specimen of timber, in accordance with IS 1708 (Parts 1 to 18) and does not take into account the effect of naturally occurring characteristics and other factors.

**3.16 Inside Location** — A position in buildings in which

timber remains continuously dry or protected from weather.

**3.17 Laminated Veneer Lumber** — A structural composite made by laminating veneers, 1.5 to 4.2 mm thick, with suitable adhesive and with the grain of veneers in successive layers aligned along the longitudinal (length) dimension of the composite.

**3.18 Loaded Edge Distance** — The distance measured from the centre to the edge towards which the load induced by the connector acts, and the unloaded edge distance is the one opposite to the loaded edge.

**3.19 Location** — A term generally referred to as exact place where a timber is used in building.

**3.20 Outside Location** — A position in buildings in which timbers are occasionally subjected to wetting and drying as in the case of open sheds and outdoor exposed structures.

**3.21 Sandwich, Structural** — A layered construction comprising a combination or relatively high strength facing material intimately bonded to and acting integrally with a low density core material.

**3.22 Structure, Permanent** — The structural units in timber which are constructed for a long duration and wherein adequate protection and design measures have initially been incorporated to render the structure serviceable for the required life.

**3.23 Structure, Temporary** — The structures which are erected for a short period, such as hutments at project sites, for rehabilitation, temporary defence constructions, exhibition structures, etc.

**3.24 Structural Element** — The component timber members and joints which make up a resulting structural assembly.

**3.25 Structural Grades** — The grades defining the maximum size of strength reducing natural characteristics (knots, sloping grain, etc) deemed permissible in any piece of structural timber within designated structural grade classification.

**3.26 Structural Timber** — A timber in which strength is related to the anticipated in-service use as a controlling factor in grading and selection and/or stiffness.

**3.27 Termite** — An insect of the order *Isoptera* which may burrow in the wood or wood products of a building for food or shelter.

**3.28 Wet Location** — The position in buildings in which timbers are almost continuously damp or wet in contact with the earth or water, such as piles and timber foundations.

**3.29 Check** — A separation of fibres extending along the grain which is confined to one face of a piece of wood.

**3.30 Compression Wood** — An abnormal wood which is formed on the lower sides of branches and inclined stems of coniferous trees. It is darker and harder than normal wood but relatively low in strength for its weight. It can be usually identified by wide eccentric growth rings with abnormally high proportion of growth latewood.

**3.31 Dead Knot** — A knot in which the layers of annual growth are not completely inter grown with those of the adjacent wood. It is surrounded by pitch or bark. The encasement may be partial or complete.

**3.32 Decay or Rot** — The disintegration of wood tissue caused by fungi (wood destroying) or other micro-organisms.

**3.33 Decayed Knot** — A knot softer than the surrounding wood and containing decay.

**3.34 Diameter of Knot** — The maximum distance between the two points farthest apart on the periphery of a round knot, on the face on which it becomes visible. In the case of a spike or a splay knot, the maximum width of the knot visible on the face on which it appears shall be taken as its diameter.

**3.35 Discolouration** — A change from the normal colour of the wood which does not impair the strength of the wood.

**3.36 Knot —** A branch base or limb embedded in the tree or timber by natural growth.

**3.37 Knot Hole** — A hole left as a result of the removal of a knot.

**3.38 Live Knot** — A knot free from decay and other defects, in which the fibres are firmly inter grown with those of the surrounding wood. Syn. 'Integrown knot'; cf. 'Dead Knot'.

**3.39 Loose Grain (Loosened Grain)** — A defect on a flat sawn surface caused by the separation or raising of wood fibres along the growth rings; cf. 'Raised Grain'.

**3.40 Loose Knot** — A knot that is not held firmly in place by growth or position, and that cannot be relied upon to remain in place; cf. 'Tight Knot'.

**3.41 Mould** — A soft vegetative growth that forms on wood in damp, stagnant atmosphere. It is the least harmful type of fungus, usually confined to the surface of the wood.

**3.42 Pitch Pocket** – An accumulation of resin between growth rings of coniferous wood as seen on the cross-section.

**3.43 Sap Stain** — Discolouration of the sapwood mainly due to fungi.

**3.44 Sapwood —** The outer layer of log, which in the growing tree contain living cells and food material. The sapwood is usually lighter in colour and is readily attacked by insects and fungi.

**3.45 Shake** — A partial or complete separation between adjoining layers of tissues as seen in end surfaces.

**3.46 Slope of Grain** — The inclination of the fibres to the longitudinal axis of the member.

**3.47 Sound Knot** — A tight knot free from decay, which is solid across its face, and at least as hard as the surrounding wood.

**3.48 Split** — A crack extending from one face of a piece of wood to another and runs along the grain of the piece.

**3.49 Tight Knot —** A knot so held by growth or position as to remain firm in position in the piece of wood; cf. 'Loose Knot'.

**3.50 Wane** — The original rounded surface of a tree remaining on a piece of converted timber.

**3.51 Warp** — A deviation in sawn timber from a true plane surface or distortion due to stresses causing departure from a true plane.

**3.52 Worm Holes** — The cavities caused by worms.

## 4 SYMBOLS

For the purpose of this standard, the following letter symbols shall have the meaning indicated against each:

$A$ = Projected area of bolt in main member ($t' \times d_3$), mm$^2$

$B$ = Width of the beam, mm

$C$ = Concentrated load, N

$D$ = Depth of beam, mm

$D_1$ = Depth of beam at the notch, mm

$D_2$ = Depth of notch, mm

$D$ = Dimension of least side of column, mm

$d_1$ = Least overall width of box column, mm

$d_2$ = Least overall dimension of core in box column, mm

$d_3$ = Diameter of bolt, mm

$d_f$ = Bolt-diameter factor

$e$ = Length of the notch measured along the beam span from the inner edge of the support to the farthest edge of the notch, mm

$E$ = Modulus of elasticity in bending, N/mm$^2$

$F$ = Load acting on a bolt at an angle to grain, N

$f_{ab}$ = Calculated bending stress in extreme fibre, N/mm$^2$

$f_{ac}$ = Calculated average axial compressive stress, N/mm$^2$

$f_{at}$ = Calculated axial tensile stress, N/mm$^2$

$f_b$ = Permissible bending stress on the extreme fibre, N/mm$^2$

$f_c$ = Permissible stress in axial compression, N/mm$^2$

$f_{cn}$ = Permissible stress in compression normal (perpendicular) to grain, N/mm$^2$

$f_{cp}$ = Permissible stress in compression parallel to grain, N/mm$^2$

$f_c\theta$ = Permissible compressive stress in the direction of the line action of the load, N/mm$^2$

$f_t$ = Permissible stress in tension parallel to grain, N/mm$^2$ [extreme fibre stress in bending and tension ($f_b$) is safe practical estimate of tensile strength due to mode of failure in beams]

$H$ = Grain horizontal shear stress, N/mm$^2$

$I$ = Moment of inertia of a section, mm$^4$

$K$ = Coefficient in deflection depending upon type and criticality of loading on beam

$K_1$ = Modification factor for change in slope of grain

$K_2$ = Modification factor for change in duration of loadings

$K_3$, $K_4$, $K_5$, and $K_6$ = Form factors

$K_7$ = Modification factor for bearing stress

$K_8$ = Constant = $0.584\sqrt{\frac{E}{f_{cp}}}$

$K_9$ = Constant = $\frac{\pi}{2}\sqrt{\frac{UE}{5q\ f_{cp}}}$

$K_{10}$ = Constant = $0.584\sqrt{\frac{2.5E}{f_{cp}}}$

$L$ = Span of a beam or truss, mm

$M$ = Maximum bending moment in beam, N-mm (or kN-m)

$P$ = Load on bolt parallel to grain, N

$p_1$ = Ratio of the thickness of the compression flange to the depth of the beam

$q$ = Constant for particular thickness of plank

$q_1$ = Ratio of the total thickness of web or webs to the overall width of the beam

$S$ = Unsupported overall length of column, mm

$t$ = Nominal thickness of planks used in forming box type column, mm

$t'$ = Thickness of main member, mm

$U$ = Constant for a particular thickness of the plank

$V$ = Vertical end reaction or shear at a section, N

$W$ = Total uniform load, N

$x$ = Distance from reaction to load, mm

$y$ = Factor determining the value of form factor $K_4$

$\delta$ = Deflection at middle of beam, mm

$\theta$ = Angle of load to grain direction

$Z$ = Section modulus of beam, $mm^3$

## 5 MATERIALS

### 5.1 Species of Timber

The species of timber recommended for constructional purposes are given in Table 1.

**5.1.1** *Grouping*

Species of timber recommended for constructional purposes are classified in three groups on the basis of their strength properties, namely, modulus of elasticity ($E$) and extreme fibre stress in bending and tension ($f_b$).

The characteristics of these groups are as given below:

a) *Group A – E* above $12.6 \times 10^3$ N/mm$^2$ and $f_b$ above 18.0 N/mm$^2$.

b) *Group B – E* above $9.8 \times 10^3$ N/mm$^2$ and up to $12.6 \times 10^3$ N/mm$^2$ and $f_b$ above 12.0 N/mm$^2$ and up to 18.0 N/mm$^2$.

c) *Group C – E* above $5.6 \times 10^3$ N/mm$^2$ and up to $9.8 \times 10^3$ N/mm$^2$ and $f_b$ above 8.5 N/mm$^2$ and up to 12.0 N/mm$^2$.

NOTE — Modulus of elasticity given above is applicable for all locations and extreme fibre stress in bending is for inside location.

**5.1.2** Safe permissible stresses for the species of timber (classified into three groups in **5.1.1**) are given in Table 1.

**5.1.3** Timber species may be identified in accordance with IS 4970.

**5.2** The general characteristics like durability and treatability of the species are also given in Table 1. Species of timber other than those recommended in Table 1 may be used, provided the basic strength properties are determined and found in accordance with **5.1.1**.

Other species can be used at the risk of larger sections and economy. The choice may ensure that structural members do not remain much under stressed in a specific design.

NOTE — For obtaining basic stress figures of the unlisted species, reference may be made to the Forest Research Institute, Dehradun.

**5.3** The permissible lateral strength (in double shear) of mild steel wire nail shall be as given in Table 2 and Table 3 for different species of timber.

### 5.4 Moisture Content in Timber

The permissible moisture content of timber for various positions in buildings shall be as given in Table 4.

### 5.5 Sawn Timber

The cut sizes of timber stock for structural purposes shall be in accordance with IS 4891.

**5.5.1** *Sizes*

Preferred cut sizes of timber for use in structural components shall be as given in Table 5, Table 6 and Table 7.

## Table 1 Safe Permissible Stresses for the Species of Timber

[*Clauses* 4.1, 4.2, 4.7.1.3(b), 5.4.1, 5.4.2 *and* 6.5.8.3.1(b)]

| Species | | Locality From Where Tested | Average Density at 12 Per-cent Moisture Content | Modulus of Elasticity (All Grades and All Locations x$10^3$ | Permissible Stress in N/mm$^2$ for Grade I | | | | | | | | | | | | Preservative Characters | | [3)]Refrac-teriness to all Season-ing |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Bending and Tension Along Grain, Extreme Fibre Stress | | | Shear all Locations | | Compression Parallel to Grain | | | Compression Perpendicular to Grain | | | [1)]Durabilit y Class | [2)]Treat-ability Grade | |
| Botanical Name | Trade Name | | kg/m$^3$ | N/mm$^2$ | Inside Location | Outside Location | Wet Location | Horizontal | Along Grain | Inside Location | Outside Location | Wet Location | Inside Location | Outside Location | Wet Location | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) |
| **GROUP A** | | | | | | | | | | | | | | | | | | |
| *Acacia catectou* | Khair (KHA) | U.P. | 1 009 | 13.44 | 20.1 | 16.8 | 13.4 | 1.6 | 2.2 | 13.8 | 12.3 | 10.1 | 7.7 | 6.0 | 4.9 | I | — | A |
| *Acacia chundra* | Red kutch | M.P. | 1 086 | 16.79 | 26.5 | 22.0 | 17.6 | 2.2 | 3.2 | 17.9 | 15.9 | 13.0 | 10.9 | 8.4 | 6.9 | — | — | A |
| *Albizia odoratissima* | Kala siris (KSI) | Chennai | 737 | 13.54 | 18.7 | 15.6 | 12.5 | 1.5 | 2.2 | 13.3 | 11.8 | 9.6 | 7.3 | 5.6 | 4.6 | I | e | B |
| *Bruguiera spp.* | Bruguiera (BSV) (Mangrove) | Andmans | 897 | 17.68 | 21.9 | 18.3 | 14.6 | 1.2 | 1.7 | 14.3 | 12.7 | 10.4 | 5.5 | 4.3 | 3.5 | III | — | — |
| *Grewia tiliifolia* | Dhaman (DHA) | Chennai | 788 | 14.82 | 18.3 | 15.2 | 12.2 | 1.3 | 1.9 | 12.0 | 10.7 | 8.7 | 6.0 | 4.7 | 3.8 | III | d | B |
| *Hopea utilis (Balano carpus utilis)* | Karung | Chennai | 987 | 16.91 | 25.1 | 20.9 | 16.7 | 1.5 | 2.2 | 16.4 | 14.6 | 11.9 | 9.3 | 7.3 | 5.9 | — | — | — |
| *Hopea glabra* | Hopea (HOP) | Chennai | 1 081 | 14.79 | 21.3 | 17.8 | 14.2 | 1.5 | 2.2 | 14.5 | 12.9 | 10.6 | 9.9 | 7.7 | 6.3 | I | — | A |
| *Hopea parviflora* | Hopea (HOP) | Chennai | 923 | 13.03 | 18.6 | 15.5 | 12.4 | 1.3 | 1.8 | 13.2 | 11.8 | 9.6 | 9.2 | 7.3 | 6.0 | I | e | A |
| *Manilota polyandra (Syn. Cynometra polyandra)* | Ping (PIG) | Assam | 903 | 13.20 | 19.1 | 15.9 | 12.7 | 1.3 | 1.8 | 1.2 | 10.4 | 8.5 | 5.7 | 4.4 | 3.6 | III | b | A |
| *Mesua ferrea* | Mesua (MES) | Assam | 965 | 16.30 | 23.3 | 19.4 | 15.5 | 1.2 | 1.8 | 15.5 | 13.8 | 11.3 | 5.9 | 4.6 | 3.7 | I | — | A |
| *Mimusops littoralis* | Bullet-wood (BUL) | S.Andaman | 1 103 | 17.39 | 22.7 | 18.9 | 15.1 | 1.5 | 2.1 | 14.2 | 12.7 | 10.4 | 11.3 | 8.8 | 7.2 | I | — | A |
| *Pesciloneuron indicum* | Ballagi (BAL) | Chennai | 1 139 | 16.29 | 22.4 | 18.7 | 15.0 | 1.5 | 2.2 | 14.7 | 13.1 | 10.7 | 8.7 | 6.8 | 5.5 | I | e | A |
| *Pterocarpus Scantalinus* | Red sanders (MA) | Chennai | 1 121 | 12.73 | 25.0 | 20.9 | 16.7 | 1.7 | 2.5 | 18.1 | 16.1 | 13.2 | 11.8 | 9.2 | 7.5 | — | — | A |
| *Sageraea elliptica* | Chooi (COC) | Andmans | 869 | 15.06 | 21.5 | 17.9 | 14.3 | 1.1 | 1.5 | 12.5 | 11.1 | 9.1 | 5.3 | 4.1 | 3.4 | — | — | A |
| *Stereospermun celonoides* | Padri (PAD) | Chennai | 731 | 12.94 | 19.0 | 15.8 | 12.7 | 1.1 | 1.6 | 11.9 | 10.6 | 8.7 | 4.0 | 3.1 | 2.6 | III | — | B |
| *Vitex altissima* | Milla (MIL) | Maharashtra | 937 | 13.01 | 18.2 | 15.2 | 12.1 | 1.2 | 1.7 | 12.6 | 11.2 | 9.2 | 9.5 | 7.4 | 6.1 | I | e | A |
| **GROUP B** | | | | | | | | | | | | | | | | | | |
| *Albizzia lebbeck* | Kokko (KOK) | Andaman | 642 | 11.17 | 13.4 | 11.2 | 9.0 | 1.1 | 1.5 | 9.0 | 8.0 | 6.5 | 4.4 | 3.4 | 2.8 | I | e | B |
| *Anogeissus latifolia* | Dhaura, Axle wood (AXL) (Bakli) | U.P. | 892 | 10.55 | 16.1 | 13.4 | 10.7 | 1.1 | 1.6 | 9.1 | 8.1 | 6.6 | 4.7 | 3.7 | 3.0 | I | e | A |
| *Artocarpus hirsulus* | Aini (AIH) | Chennai | 600 | 10.45 | 15.0 | 12.5 | 10.0 | 0.7 | 1.1 | 10.4 | 9.2 | 7.5 | 3.3 | 2.6 | 2.1 | I | — | B |
| *Acacia nilotica* | Babul (BAB) | U.P. | 797 | 97.70 | 15.5 | 12.9 | 10.3 | 1.4 | 2.1 | 8.9 | 7.9 | 6.4 | 5.2 | 4.0 | 3.3 | I | b | B |
| *Acacia ferruginea* | Safed khair | Maharashtra | 993 | 12.28 | 23.0 | 19.2 | 15.3 | 1.7 | 2.4 | 13.9 | 12.4 | 10.1 | 9.9 | 7.7 | 6.3 | — | — | — |

**Table 1** — (*Continued*)

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Acrocarpus fraxinifolius* | Mundani (MUN) | Chennai | 690 | 12.59 | 16.1 | 13.4 | 10.8 | 1.2 | 1.8 | 10.5 | 9.4 | 7.7 | 4.6 | 3.6 | 2.9 | III | c | B |
| *Aglaia odulis* | Aglaia (AGL) | Assam | 815 | 12.56 | 18.2 | 15.2 | 12.1 | 1.4 | 2.0 | 10.1 | 8.9 | 7.3 | 4.4 | 3.4 | 2.8 | — | — | A |
| *Anogeissus acuminota* | Yon | Orissa | 844 | 11.67 | 17.6 | 14.7 | 11.7 | 1.3 | 1.8 | 10.8 | 9.6 | 7.9 | 5.1 | 4.0 | 3.3 | — | — | A |
| *Atalanlia monophylla* | Jungli—nimbu (JHI) | Orissa | 897 | 10.31 | 16.7 | 13.9 | 11.1 | 1.5 | 2.1 | 11.3 | 10.0 | 8.2 | 6.3 | 4.9 | 4.0 | — | — | — |
| *Altingia excelsa* | Jutili (JUT) | Assam | 795 | 11.37 | 17.1 | 14.3 | 11.4 | 1.2 | 1.8 | 11.0 | 9.8 | 8.0 | 6.8 | 5.3 | 4.4 | II | e | A |
| *Amoora spp.* | Amari (AMA) | Bengal | 625 | 1.05 | 13.4 | 1.1 | 9.2 | 0.9 | 1.3 | 8.4 | 7.4 | 6.0 | 3.7 | 2.9 | 2.4 | II | d | B |
| *Bucklandia populnea (Syn Exbucklandia populnea)* | Pipli (PIP) | W.Bengal | 672 | 9.89 | 12.8 | 10.7 | 8.6 | 1.1 | 1.5 | 7.9 | 7.0 | 5.7 | 3.5 | 2.7 | 2.2 | III | e | C |
| *Cassia fistula* | Amaltas (AMT) | U.P. | 865 | 11.80 | 19.2 | 16.0 | 12.8 | 1.4 | 2.0 | 12.3 | 10.9 | 8.9 | 7.2 | 5.6 | 4.6 | I | — | A |
| *Carallia lucida* | Maniawaga | Assam | 748 | 12.60 | 18.4 | 15.3 | 12.3 | 1.2 | 1.7 | 11.4 | 10.1 | 8.3 | 5.9 | 4.6 | 3.8 | — | — | — |
| *Canarium strictum* | Dhup | Chennai | 655 | 11.86 | 13.3 | 11.1 | 8.9 | 0.9 | 1.2 | 8.1 | 7.2 | 5.9 | 2.8 | 2.2 | 1.8 | III | — | C |
| *Cassia sienea* | Kasod | M.P. | 820 | 10.50 | 15.4 | 12.8 | 10.9 | 1.0 | 1.4 | 10.8 | 9.6 | 7.9 | 5.5 | 4.3 | 3.5 | — | — | — |
| *Casuerina equisetifolia* | Casuarina (CAS) | Orissa | 769 | 11.44 | 14.6 | 12.2 | 9.8 | 1.3 | 1.8 | 8.2 | 7.3 | 5.9 | 4.0 | 3.1 | 2.5 | III | e | A |
| *Celophyllum temculosum* | Poon (POO) | Maharashtra | 657 | 9.77 | 13.4 | 11.2 | 9.0 | 0.8 | 1.1 | 8.6 | 7.7 | 6.3 | 2.8 | 2.2 | 1.8 | II | — | B |
| *Chloroxylon swielenia* | Satin wood (CFI) | M.P. | 865 | 11.69 | 18.2 | 15.1 | 12.1 | 1.4 | 2.0 | 10.9 | 9.7 | 8.0 | 6.3 | 4.9 | 4.0 | III | — | A |
| *Cullenia resayoana (Syn C. execelsa)* | Karani (KAP) | Chennai | 625 | 12.43 | 14.7 | 12.3 | 9.8 | 0.6 | 0.9 | 9.0 | 8.0 | 6.6 | 2.7 | 2.1 | 1.7 | III | b | C |
| *Diploknema butyracea (Syn Bassia butyrance)* | Hill mahua (HMA) | S.Andaman | 780 | 10.64 | 15.3 | 12.8 | 10.2 | 1.0 | 1.5 | 9.9 | 8.8 | 7.2 | 6.6 | 5.2 | 4.2 | — | — | — |
| *Dyscxylum malebaricum* | White ceda (WCE) | Chennai | 745 | 10.92 | 13.2 | 11.0 | 8.8 | 1.0 | 1.4 | 8.0 | 7.1 | 5.8 | 3.1 | 2.4 | 1.9 | I | — | B |
| *Dipterocarpus grandiflorus* | Gurjan (GUR) | N.Andaman | 758 | 11.71 | 12.5 | 10.5 | 8.4 | 0.8 | 1.1 | 7.9 | 7.1 | 5.8 | 2.7 | 2.1 | 1.7 | I | — | B |
| *Dipterocarpus macrocarpus* | Hollong (HOL) | Assam | 726 | 13.34 | 14.5 | 12.0 | 9.6 | 0.8 | 1.1 | 8.8 | 7.9 | 6.4 | 3.5 | 2.7 | 2.2 | III | a | B |
| *Dichopsis polyantha (Syn Palaquium polyanthum)* | Tali (TAL) | Assam | 734 | 11.24 | 14.9 | 12.4 | 10.0 | 1.1 | 1.6 | 9.9 | 8.8 | 7.2 | 4.7 | 3.7 | 3.0 | — | — | B |
| *Dichopsis elliptica (Syn Palaquium ellipticum)* | Pali (PAL) | Chennai | 606 | 11.86 | 13.9 | 11.6 | 9.3 | 0.7 | 1.0 | 8.5 | 7.5 | 6.2 | 2.9 | 2.2 | 1.8 | I | e | B |
| *Diospyros micropylla* | Ebony (EBO) | Maharashtra | 776 | 12.15 | 14.2 | 11.9 | 9.5 | 0.9 | 1.3 | 8.3 | 7.3 | 6.0 | 3.3 | 2.6 | 2.1 | — | — | A |
| *Diospyros pyrrhocarpus* | Ebony (EBO) | N.Andaman | 843 | 9.93 | 13.5 | 11.2 | 9.0 | 1.0 | 1.4 | 7.9 | 7.0 | 5.7 | 4.0 | 3.1 | 2.5 | III | — | A |
| *Dipterocarpus bourdilloni* | Gurjan (GUR) (Blue gum) (BLN) | Kerala | 699 | 12.71 | 13.6 | 11.3 | 9.0 | 0.7 | 1.0 | 7.8 | 6.9 | 5.7 | 2.5 | 1.9 | 1.6 | — | — | B |
| *Eucalyptus globulus* | Eucalyptus | Chennai | 912 | 14.83 | 15.9 | 13.2 | 10.6 | 10.3 | 1.5 | 9.0 | 8.0 | 6.5 | 3.4 | 2.6 | 2.1 | I | e | A |
| *Eucalyptus ougenioides* | Eucalyptus | Chennai | 853 | 11.47 | 16.4 | 13.6 | 10.9 | 1.2 | 1.7 | 11.3 | 10.0 | 8.2 | 7.6 | 5.9 | 4.8 | — | — | — |
| *Eugenia gardnery* | Jaman (JAM) | Chennai | 952 | 11.94 | 14.8 | 12.3 | 9.8 | 1.1 | 1.6 | 9.2 | 8.2 | 6.7 | 5.8 | 4.5 | 3.7 | III | d | — |
| *Eugenia jambolana* | Jaman (JAM) | U.P. | 778 | 10.94 | 16.0 | 13.3 | 10.6 | 1.2 | 1.7 | 9.7 | 8.6 | 7.1 | 4.7 | 3.7 | 3.0 | | | |
| *Exbucklandia populnea* | Pipli (PIP) | W.Bengal | 678 | 11.44 | 14.2 | 11.9 | 9.5 | 1.0 | 1.43 | 7.8 | 6.9 | 5.7 | 2.9 | 2.3 | 1.9 | III | — | C |
| *Gluta travancorice* | Gluta (GLU) | Chennai | 726 | 12.73 | 13.5 | 11.3 | 9.0 | 0.9 | 1.3 | 9.0 | 8.0 | 6.6 | 4.0 | 3.1 | 2.5 | I | — | A |
| *Grewia veslita* | Dhaman (DHA) | W.Bengal | 758 | 12.00 | 15.4 | 12.6 | 10.3 | 1.4 | 2.0 | 9.1 | 8.1 | 6.6 | 4.1 | 3.2 | 2.6 | III | d | B |
| *Heritiera spp.* | Sundri (SUN) | Assam | 872 | 13.37 | 17.9 | 14.9 | 11.9 | 1.3 | 1.8 | 11.0 | 9.8 | 8.0 | 6.5 | 5.0 | 4.1 | I | — | A |
| *Kingiodendron pinnatum (Syn Hardwickia pinnata)* | Piney (PIN) | Chennai | 617 | 10.62 | 13.2 | 11.0 | 8.8 | 0.4 | 1.3 | 8.2 | 7.3 | 6.0 | 2.9 | 2.2 | 1.8 | — | — | B |
| *Kayea floribund* | Karal | Assam | 813 | 10.88 | 16.8 | 14.0 | 1.1 | 1.1 | 1.6 | 10.1 | 9.0 | 7.3 | 4.4 | 3.4 | 2.8 | III | — | — |
| *Lagerstromia lanceolata* | Benteak (BEN) | Chennai | 617 | 10.76 | 12.7 | 10.6 | 8.5 | 0.8 | 1.2 | 8.2 | 7.3 | 5.9 | 3.4 | 2.6 | 2.2 | I | e | B |
| *Lagerstromia parviflora* | Lendi (LEN) | U.P. | 734 | 10.97 | 14.3 | 11.9 | 9.5 | 1.1 | 1.6 | 8.7 | 7.7 | 6.3 | 3.7 | 2.9 | 2.4 | I | e | A |

**Table 1** — (*Continued*)

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Mimusops elengi* | Bakul (BKL) | Chennai | 885 | 12.39 | 17.3 | 14.4 | 11.5 | 1.3 | 1.8 | 11.0 | 9.8 | 8.0 | 5.6 | 4.3 | 3.6 | I | — | A |
| *Machilus macrantha* | Machilus (MAC) | W.Bengal | 692 | 10.00 | 12.4 | 10.3 | 8.3 | 1.0 | 1.5 | 8.2 | 7.3 | 6.0 | 3.5 | 2.7 | 2.2 | III | e | B/C |
| *Miliuse tyomentosa (Syn Saccopapetalum tomentosum)* | Hoom (HOO) | Maharashtra | 745 | 11.06 | 14.8 | 12.3 | 9.9 | 0.9 | 1.3 | 9.7 | 8.6 | 7.0 | 3.5 | 2.7 | 2.2 | III | — | B |
| *Pommetia pinnata* | — | Andaman | 788 | 12.90 | 14.3 | 11.9 | 9.5 | 1.1 | 1.6 | 9.1 | 8.0 | 6.6 | 4.0 | 3.1 | 2.5 | — | — | — |
| *Pterocarpus dolbergioides* | Padauk (PAD) | N.Andaman | 721 | 11.24 | 17.1 | 14.3 | 11.4 | 1.0 | 1.5 | 12.0 | 10.7 | 8.7 | 5.5 | 4.3 | 3.5 | I | c | B |
| *Mesua assamica* | Kayea | Assam | 842 | 12.83 | 17.4 | 14.5 | 11.6 | 1.0 | 1.4 | 11.7 | 10.4 | 8.5 | 5.3 | 4.1 | 3.3 | II | e | — |
| *Pterocarpus marsupium* | Bijasal (BIJ) | Maharashtra | 803 | 10.25 | 14.9 | 12.4 | 9.9 | 0.9 | 1.3 | 9.1 | 8.1 | 6.6 | 4.1 | 3.2 | 2.6 | I | e | B |
| *Fraxlnus macrantha* | Ash (ASH) | U.P. | 712 | 10.69 | 15.0 | 12.5 | 10.0 | 1.2 | 1.7 | 8.5 | 7.6 | 6.2 | 4.3 | 3.3 | 2.7 | III | — | B |
| *Fraxlnus execlsior* | Ash (ASH) | Punjab | 719 | 10.41 | 14.8 | 12.3 | 9.8 | 1.2 | 1.7 | 8.1 | 7.2 | 5.8 | 3.3 | 2.6 | 2.1 | III | — | B |
| *Planchonia valida (Syn P. andamanica)* | Red bombwe (RBO) | Andaman | 913 | 13.10 | 16.1 | 13.4 | 10.7 | 1.0 | 1.4 | 10.8 | 9.6 | 7.9 | 4.9 | 3.8 | 3.1 | III | — | — |
| *Quercus lamellosa* | Oak | W.Bengal | 87 | 12.44 | 14.5 | 12.1 | 9.7 | 1.2 | 1.7 | 8.7 | 7.8 | 6.4 | 3.8 | 2.9 | 2.4 | II | c | A |
| *Quercus griffithii* | Oak | Meghalaya | 974 | 10.06 | 13.1 | 10.9 | 8.8 | 1.1 | 1.6 | 8.0 | 7.1 | 5.8 | 4.6 | 3.6 | 2.9 | — | — | A |
| *Quercus incane* | Oak | Punjab | 1008 | 10.82 | 15.8 | 13.1 | 10.5 | 1.2 | 1.8 | 8.7 | 7.8 | 6.3 | 5.0 | 3.9 | 3.2 | — | — | A |
| *Quercus lineate* | Oak | W.Bengal | 874 | 12.63 | 15.2 | 12.7 | 10.1 | 1.2 | 1.7 | 9.6 | 8.6 | 7.0 | 5.3 | 4.1 | 3.4 | II | c | A |
| *Quercus semecarpifolia* | — | Punjab | 834 | 11.58 | 15.8 | 13.1 | 10.5 | 1.3 | 1.8 | 8.3 | 7.3 | 6.0 | 3.8 | 2.9 | 2.4 | — | — | A |
| *Shorea robusta*[4)] | Sal (SAL) | M.P. | 805 | 12.67 | 16.9 | 14.0 | 11.2 | 0.9 | 1.3 | 10.6 | 9.4 | 7.7 | 4.6 | 3.5 | 2.9 | I | e | A |
| *Soymida fabrifuga* | Rohini (ROH) | Chennai | 1116 | 12.22 | 21.5 | 17.9 | 14.4 | 1.6 | 2.3 | 15.0 | 13.3 | 10.9 | 12.9 | 10.0 | 8.2 | I | — | A |
| *Shorea talura* | — | Maharashtra | 721 | 12.20 | 16.8 | 14.0 | 11.2 | 1.1 | 1.6 | 12.6 | 11.2 | 9.2 | 6.8 | 5.3 | 4.3 | — | — | — |
| *Plerygota alata (Syn. Sterculia alata)* | Narikel (NAR) | Assam | 593 | 10.95 | 13.4 | 11.8 | 8.9 | 0.8 | 1.2 | 8.2 | 7.3 | 6.0 | 2.7 | 2.1 | 1.7 | III | — | C |
| *Syzygium cumini* | Jaman (JAM) | Assam | 841 | 10.55 | 14.8 | 12.4 | 9.9 | 1.1 | 1.6 | 9.0 | 8.0 | 6.5 | 6.9 | 5.4 | 4.4 | II | e | A |
| *Terminalia bellirica* | Bahera (BAH) | U.P. | 729 | 10.19 | 13.6 | 11.3 | 9.0 | 1.0 | 1.4 | 8.4 | .7.5 | 6.1 | 3.7 | 2.8 | 2.3 | III | b | B |
| *Terminalia chebula* | Myrobalan (MYR) | — | 918 | 12.37 | 17.1 | 14.2 | 11.4 | 1.1 | 1.6 | 1.2 | 10.4 | 8.5 | 6.7 | 5.2 | 4.3 | II | c | A |
| *Terminalia citrina* | — | Assam | 755 | 11.89 | 17.1 | 14.3 | 11.4 | 1.1 | 1.6 | 10.8 | 9.6 | 7.9 | 5.0 | 3.9 | 3.2 | — | — | — |
| *Terminalia manii* | Black-chuglam (BCH) | S.Andaman | 822 | 12.66 | 16.8 | 14.0 | 11.2 | 1.1 | 1.6 | 10.3 | 9.2 | 7.5 | 5.1 | 4.0 | 3.2 | II | a | B |
| *Tectona grandis* | Teak (TEA) | U.P. | 660 | 9.97 | 15.5 | 12.9 | 10.3 | 1.2 | 1.6 | 9.4 | 8.3 | 6.8 | 4.5 | 3.5 | 2.8 | I | e | B |
| *Terminalia paniculate* | Kindal (KIN) (WCH) | Maharashtra | 765 | 10.57 | 13.1 | 10.9 | 8.7 | 0.9 | 1.3 | 8.6 | 7.7 | 6.3 | 3.6 | 2.8 | 2.3 | I | c | A |
| *Alreminalia alata* | Laurel (LAU), Sain | Chennai | 906 | 10.54 | 15.1 | 12.5 | 10.0 | 1.1 | 1.6 | 9.4 | 8.4 | 6.8 | 6.2 | 4.8 | 4.0 | I | b | A |
| *Terminalia bilata* | White-chuglam | S.Andaman | 690 | 12.38 | 15.5 | 13.0 | 10.4 | 0.9 | 1.2 | 9.8 | 8.7 | 7.1 | 3.6 | 2.8 | 2.3 | III | e | B |
| *Thespesia populnea* | Bhendi (BHE) | Maharashtra | 766 | 10.36 | 18.9 | 15.8 | 12.6 | 1.3 | 1.9 | 11.3 | 10.0 | 8.2 | 4.4 | 3.4 | 2.8 | — | — | B |
| *Xylia xylocarpa* | Irul (IRU) | Maharashtra | 839 | 11.63 | 16.2 | 13.5 | 10.8 | 1.3 | 1.8 | 10.9 | 9.7 | 7.9 | 7.8 | 6.0 | 4.9 | I | e | A |
| *Zanthoxylum budranga* | Mullilam (MUL) | W.Bengal | 587 | 10.65 | 14.7 | 12.2 | 9.8 | 0.9 | 1.2 | 9.5 | 8.4 | 6.9 | 3.4 | 2.6 | 2.1 | I | e | B |
| *Adina oligocephala* | — | Arunachal | 715 | 11.17 | 15.2 | 12.7 | 10.1 | 1.2 | 1.7 | 10.3 | 9.2 | 7.5 | 4.0 | 3.1 | 2.4 | — | — | — |
| *Castanopsis indica* | Chestnut | Meghalaya | 688 | 12.54 | 14.8 | 12.3 | 9.9 | 1.0 | 1.4 | 9.8 | 8.7 | 7.1 | 3.4 | 2.7 | 2.2 | — | — | B |
| *Eucalyptus citriodara* | Eucalyptus | Nilgiri | 831 | 12.12 | 17.3 | 14.4 | 11.5 | 1.4 | 2.0 | 11.0 | 9.8 | 8.0 | 4.2 | 3.3 | 2.7 | — | — | — |
| *Eucalyptus citriodata* | Eucalyptus | Ooty | 725 | 9.35 | 15.4 | 12.9 | 10.3 | 1.0 | 1.4 | 8.6 | 7.6 | 6.3 | 3.0 | 2.4 | 2.0 | — | — | — |
| *Eucalytus tereticornis* | Eucalyptus | Chennai | 777 | 11.05 | 16.7 | 13.9 | 11.1 | 1.0 | 1.4 | 9.7 | 8.6 | 7.1 | 3.4 | 2.6 | 2.2 | III | e | — |
| *Zanthoxylum rhetsa* | Mullilam (MUL) | Maharashtra | 609 | 13.02 | 15.5 | 12.9 | 10.3 | 1.09 | 1.55 | 9.2 | 8.2 | 6.7 | 3.9 | 3.0 | 2.5 | I | e | — |

**Table 1** — (*Continued*)

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GROUP C** | | | | | | | | | | | | | | | | | | |
| *Tbizia procera* | White siris | U.P. | 643 | 9.02 | 13.4 | 11.2 | 8.9 | 1.0 | 1.4 | 8.5 | 7.6 | 6.2 | 4.3 | 3.3 | 2.7 | I | c | B |
| *Artocarpus lakocha* | Lakooch (LAK) | U.P. | 647 | 6.14 | 10.0 | 8.3 | 6.7 | 1.0 | 1.4 | 5.3 | 4.7 | 3.8 | 2.8 | 2.2 | 1.8 | I | — | B |
| *Artocarpus hetarophyllus (Syn. A. Integrifolia)* | Jack, kathal (KAT) | Chennai | 617 | 9.46 | 13.9 | 11.6 | 9.2 | 1.0 | 1.5 | 9.3 | 8.3 | 6.8 | 4.5 | 3.5 | 2.9 | I | d | B |
| *Aphanamixis polystachya (Syn. Amoora rehituka)* | Pitraj (PIT) | West Bengal | 668 | 8.98 | 12.3 | 10.2 | 8.2 | 1.1 | 1.5 | 8.0 | 7.1 | 5.8 | 4.0 | 3.1 | 2.6 | I | — | B |
| *Adina cordifolia*[4)] | Haldu (HAL) | U.P. | 663 | 8.54 | 13.3 | 11.1 | 8.9 | 1.0 | 1.4 | 8.7 | 7.7 | 6.3 | 4.4 | 3.4 | 2.8 | III | a | B |
| *Anthocephyalus chinensis (Syn. A. Cadamba)* | Kadam (KAD) | — | 485 | 1.88 | 9.7 | 8.1 | 5.4 | 0.7 | 1.0 | 5.9 | 5.3 | 4.3 | 1.9 | 1.5 | 1.2 | III | a | — |
| *Arlocarpus chaplasha* | Chaplash (CHP) | Assam | 515 | 9.11 | 13.2 | 11.0 | 8.8 | 0.9 | 1.2 | 8.5 | 7.5 | 6.2 | 3.6 | 2.8 | 2.3 | III | d | B |
| *Acacia leucophloea* | Hiwar (HIW) | M.P. | 737 | 7.85 | 13.4 | 11.2 | 9.0 | 1.0 | 1.5 | 7.5 | 6.7 | 5.4 | 4.5 | 3.5 | 2.8 | — | — | A |
| *Acacia melanoxylone* | Black wood | Chennai | 630 | 9.45 | 13.0 | 10.8 | 8.7 | 1.1 | 1.5 | 7.6 | 6.8 | 5.5 | 3.2 | 2.5 | 2.0 | — | — | — |
| *Acacia mearnsii (Syn. A. mollissima)* | Black wattle | Chennai | 669 | 6.10 | 10.4 | 8.6 | 6.9 | 0.8 | 1.2 | 6.0 | 5.4 | 4.4 | 2.3 | 1.8 | 1.5 | — | — | — |
| *Accer spp.* | Maple (MAP) | Punjab, U.P. | 551 | 7.35 | 9.9 | 8.2 | 6.5 | 0.9 | 1.3 | 5.5 | 4.9 | 4.0 | 2.1 | 1.7 | 1.4 | III | — | B |
| *Aegla marmalos (Syn. Intsia bijuga)* | Bael (BEL) | U.P. | 890 | 8.81 | 13.5 | 11.2 | 9.0 | 1.4 | 2.0 | 8.8 | 7.8 | 6.4 | 6.8 | 5.3 | 4.3 | III | — | B |
| *Afzelia bijuga* | — | Andaman | 705 | 9.16 | 13.2 | 11.0 | 8.8 | 1.1 | 1.5 | 7.9 | 7.1 | 5.8 | 4.0 | 3.1 | 2.6 | — | — | — |
| *Ailanthus grandis* | Gokul (GOK) | West Bengal | 404 | 7.94 | 8.3 | 6.9 | 5.5 | 0.6 | 0.8 | 5.3 | 4.7 | 3.9 | 1.1 | 0.9 | 0.7 | III | — | C |
| *Anogeissus pendula* | Kardhai (KAH) | U.P. | 929 | 9.75 | 17.0 | 14.2 | 11.4 | 1.3 | 1.8 | 9.8 | 8.7 | 7.1 | 6.5 | 5.1 | 4.2 | III | — | A |
| *Anogeissus pendula* | Kardhai (KAH) | Rajasthan | 898 | 9.52 | 18.0 | 15.0 | 12.0 | 1.35 | 1.93 | 10.2 | 9.1 | 7.9 | 6.9 | 5.4 | 4.4 | III | — | A |
| *Areca nut* | — | Kerala | 833 | 9.48 | 15.2 | 12.7 | 10.2 | 1.2 | 1.6 | 10.8 | 9.6 | 7.8 | 7.3 | 5.7 | 4.7 | — | — | — |
| *Albizia lucida* | — | Arunachal, A.P. | 566 | 8.51 | 10.7 | 8.9 | 7.1 | 8.2 | 1.2 | 7.3 | 6.3 | 5.3 | 2.3 | 1.8 | 1.5 | — | — | — |
| *Azadirachta indica* | Neem (NEE) | U.P. | 836 | 8.52 | 14.6 | 12.1 | 9.7 | 1.3 | 1.8 | 10.0 | 8.9 | 7.3 | 5.0 | 3.9 | 3.2 | — | — | — |
| *Boswellia seriata* | Salai (SAA) | Bihar | 551 | 7.21 | 9.4 | 7.9 | 6.3 | 0.7 | 1.1 | 5.5 | 4.9 | 4.0 | 2.1 | 1.6 | 1.3 | I | e | C |
| *Bridelia retusa* | Kassi (KAS) | Bihar | 584 | 9.42 | 11.6 | 9.7 | 7.7 | 0.9 | 1.3 | 7.1 | 6.3 | 5.1 | 4.0 | 3.1 | 2.6 | I | e | B |
| *Betula lnoides* | Birch (BIR) | West Bengal | 625 | 9.23 | 9.6 | 8.0 | 6.4 | 0.8 | 1.1 | 5.7 | 5.0 | 4.1 | 2.2 | 1.7 | 1.4 | — | — | B |
| *Bischofia javanica* | Uriam Bishopwood (URI) | Chennai | 769 | 8.84 | 9.6 | 8.2 | 6.5 | 0.8 | 1.1 | 5.9 | 5.3 | 4.3 | 3.6 | 2.8 | 2.3 | III | — | A |
| *Burserra serrata (Syn. Protium serratum)* | Muntenga (MUR) | A.P. | 756 | 1.17 | 15.5 | 13.3 | 10.5 | 0.9 | 1.3 | 10.1 | 9.0 | 7.4 | 5.3 | 4.1 | 3.4 | II | c | — |
| *Careya arbersa* | Kumbi (KUM) | U.P. | 889 | 8.37 | 13.1 | 10.9 | 8.8 | 1.0 | 1.5 | 7.7 | 6.8 | 5.6 | 5.3 | 4.1 | 3.4 | I | e | A |
| *Cedrus deodara* | Deodar (DEO) | H.P. | 557 | 9.48 | 10.2 | 8.7 | 7.2 | 0.7 | 1.0 | 7.8 | 6.9 | 5.7 | 2.7 | 2.1 | 1.7 | I | c | C |
| *Cupressus torulosa* | Cypress (CYP) | U.P. | 506 | 8.41 | 8.8 | 7.6 | 6.2 | 0.6 | 0.8 | 6.9 | 6.2 | 5.0 | 2.4 | 1.8 | 1.5 | I | e | C |
| *Castanopsis hystrix* | Indian chestnut (ICH) | West Bengal | 624 | 9.85 | 10.6 | 8.8 | 7.0 | 0.8 | 1.2 | 6.4 | 5.7 | 4.6 | 2.7 | 2.1 | 1.7 | II | b | B |
| *Chukrasia vclutina (Syn. C. Tabularis)* | Chickrassy (CHI) | West Bengal | 666 | 8.35 | 11.8 | 9.8 | 7.9 | 1.1 | 1.5 | 7.1 | 6.3 | 5.2 | 3.9 | 3.1 | 2.5 | II | c | B |
| *Calophyllum wightianum* | Poon (POO) | Maharashtra | 689 | 8.68 | 13.5 | 11.2 | 9.0 | 1.0 | 1.4 | 8.7 | 7.8 | 6.4 | 4.0 | 3.1 | 2.5 | II | — | B |
| *Canarium strictum* | White dhup | Assam | 569 | 10.54 | 10.1 | 8.4 | 6.7 | 0.7 | 1.1 | 6.2 | 5.5 | 4.5 | 2.1 | 1.6 | 1.3 | III | — | C |
| *Chlorophora excelsa* | — | Chennai | 471 | 6.57 | 10.2 | 8.5 | 6.8 | 0.5 | 0.7 | 6.4 | 5.6 | 4.6 | 2.0 | 1.6 | 1.3 | — | — | — |

**Table 1** — (*Continued*)

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cocosnucifera* | Coconut (COC) | Kerala | 761 | 7.34 | 9.2 | 7.7 | 6.1 | 0.7 | 1.1 | 9.5 | 8.4 | 6.9 | 3.9 | 3.0 | 2.5 | — | — | — |
| *Dalbergia latifolia* | Rosewood (ROS) | M.P. | 884 | 8.39 | 12.9 | 10.8 | 8.6 | 1.1 | 1.6 | 8.0 | 7.1 | 5.8 | 4.2 | 3.3 | 2.7 | I | — | B |
| *Dalbergia sissee* | Sisso (SIS) | Punjab | 799 | 7.14 | 12.8 | 10.7 | 8.5 | 1.3 | 1.8 | 8.2 | 7.3 | 6.0 | 4.2 | 3.3 | 2.7 | I | e | B |
| *Dillemia indica* | Dillenia (DIL) | West Bengal | 617 | 8.61 | 12.1 | 10.0 | 8.0 | 0.8 | 1.2 | 7.3 | 6.5 | 5.3 | 2.7 | 2.1 | 1.7 | III | a | B |
| *Dillenia pentagyne* | Dillenia (DIL) | West Bengal | 622 | 7.56 | 11.8 | 9.9 | 7.9 | 0.9 | 1.3 | 7.1 | 6.3 | 5.2 | 3.5 | 2.7 | 2.2 | III | d | B |
| *Diospyres melanoxylon* | Ebony (EBO) | Maharashtra | 818 | 7.69 | 10.9 | 9.1 | 7.3 | 0.9 | 1.2 | 7.0 | 6.2 | 5.1 | 3.3 | 2.6 | 2.1 | II | — | A |
| *Duabanga grandiflora* | Lampati (LAP) | West Bengal | 485 | 8.38 | 9.8 | 8.2 | 6.5 | 0.6 | 0.9 | 6.4 | 5.7 | 4.7 | 1.8 | 1.4 | 1.1 | III | c | C |
| *Elesocarpus tuberculatus (Syn. D. Sonneratioides)* | Rudrak (RUD) | Chennai | 466 | 8.74 | 9.7 | 8.1 | 6.4 | 0.7 | 1.0 | 6.3 | 5.6 | 4.6 | 2.0 | 1.5 | 1.3 | — | — | C |
| *Eucalyptus hybrid* | Mysore gum (MGU) | Chennai | 753 | 6.00 | 10.2 | 8.5 | 6.8 | 0.9 | 1.2 | 7.3 | 6.5 | 5.3 | 4.0 | 3.1 | 2.5 | III | e | — |
| *Calitres rhomboidea (Syn. Frenela rhomboidea)* | — | Chennai | 607 | 6.48 | 9.2 | 7.7 | 6.1 | 0.7 | 1.0 | 6.9 | 6.1 | 5.0 | 4.0 | 3.1 | 2.6 | — | — | — |
| *Garuga pinnata* | Garuga (GAU) | U.P. | 571 | 7.58 | 11.7 | 9.7 | 7.8 | 1.0 | 1.5 | 7.2 | 6.4 | 5.3 | 3.4 | 2.6 | 2.1 | I | e | B |
| *Gmeline arborea* | Gamari (GAM) | U.P. | 501 | 7.02 | 9.8 | 8.2 | 6.6 | 0.8 | 1.2 | 5.7 | 5.0 | 4.1 | 4.2 | 3.2 | 2.7 | I | e | B |
| *Gardonia latifolia* | Gardenia (GAI) | M.P. | 705 | 7.13 | 14.1 | 11.7 | 9.4 | 1.2 | 1.7 | 8.4 | 7.4 | 6.1 | 4.6 | 3.6 | 3.0 | — | — | — |
| *Hardwickis binata* | Anjan (ANJ) | M.P. | 852 | 6.64 | 14.1 | 11.8 | 9.4 | 1.3 | 1.8 | 9.0 | 8.0 | 6.5 | 7.4 | 5.6 | 4.7 | I | e | — |
| *Heloptelea integrifolia* | Kanju (KAN) | U.P. | 592 | 7.46 | 12.0 | 10.0 | 8.0 | 0.9 | 1.3 | 6.7 | 6.0 | 4.9 | 2.8 | 2.2 | 1.8 | III | b | B |
| *Heterrophragma rexburghii* | Palang (PAL) | M.P. | 616 | 8.69 | 12.3 | 10.2 | 8.2 | 0.7 | 1.0 | 7.9 | 7.0 | 5.7 | 3.4 | 2.6 | 2.1 | — | — | — |
| *Juglans spp.* | Walnut (WAL) | U.P. | 565 | 9.00 | 9.9 | 8.3 | 6.6 | 0.9 | 1.2 | 5.8 | 5.2 | 4.2 | 2.2 | 1.7 | 1.4 | III | — | B |
| *Lagerstrosmia speciosa (Syn. L. flesregihal)* | Jarul (JAAR) | N.Andaman | 622 | 8.53 | 12.1 | 10.1 | 8.1 | 0.8 | 1.8 | 7.7 | 6.8 | 5.6 | 3.4 | 2.6 | 2.2 | II | e | B |
| *Lannea grandis (Syn. L.coromandelica)* | Jhingan (JHI) | U.P. | 557 | 5.63 | 8.5 | 7.1 | 5.7 | 0.6 | 0.9 | 4.9 | 4.4 | 3.6 | 2.2 | 1.7 | 1.4 | III | e | B |
| *Leucanena leucocephala* | Subabul (SUB) | U.P. | 673 | 6.32 | 11.6 | 9.7 | 7.8 | 1.0 | 1.5 | 7.4 | 6.6 | 5.4 | 3.8 | 3.0 | 2.4 | — | — | |
| *Lophopatalum wightianum* | Banati (BAN) | Chennai | 460 | 7.33 | 8.5 | 7.5 | 5.6 | 0.5 | 0.8 | 5.3 | 4.7 | 3.8 | 1.8 | 1.4 | 1.1 | III | — | C |
| *Madhuca longifolia varlati folia(Syn. Bassia latifolia)* | Mahua (MAU) | M.P. | 936 | 8.82 | 13.0 | 10.8 | 8.7 | 1.0 | 1.4 | 7.5 | 6.7 | 5.5 | 6.3 | 4.9 | 4.0 | I | e | A |
| *Mangifera indica* | Mango, Aam (MAN) | Orissa | 661 | 9.12 | 12.2 | 10.2 | 8.2 | 1.0 | 1.4 | 7.3 | 6.5 | 5.3 | 3.1 | 2.4 | 2.0 | III | a | C |
| *Machilus macrantha* | Machilus (MAC) | Chennai | 521 | 7.63 | 10.2 | 8.5 | 6.8 | 0.7 | 1.0 | 6.3 | 5.6 | 4.6 | 2.4 | 1.9 | 1.5 | III | e | B |
| *Mallotus philippinensis* | Raini (RAI) | U.P. | 662 | 7.51 | 10.8 | 9.0 | 7.2 | 1.0 | 1.4 | 6.0 | 5.4 | 4.4 | 2.9 | 2.3 | 1.8 | III | — | B |
| *Manglietia insignia* | — | Assam | 449 | 10.37 | 10.9 | 9.1 | 7.3 | 0.7 | 1.0 | 8.0 | 7.1 | 5.8 | 3.4 | 2.6 | 2.1 | — | — | — |
| *Michelia montana* | Champ (CHM) | West Bengal | 512 | 8.25 | 10.9 | 9.1 | 7.3 | 0.7 | 1.0 | 6.6 | 5.9 | 4.8 | 2.8 | 2.2 | 1.8 | I | — | B |
| *Mitragyna pervifolia (Syn. Stephagyne pervifolia)* | Kaim (KAI) | U.P. | 651 | 7.82 | 12.6 | 10.5 | 8.4 | 1.0 | 1.5 | 7.9 | 7.0 | 5.7 | 3.7 | 2.9 | 2.4 | III | b | B |
| *Michelia excelsa* | Champ (CHM) | West Bengal | 513 | 10.12 | 9.8 | 8.2 | 6.5 | 0.7 | 1.0 | 6.1 | 5.5 | 4.5 | 1.6 | 1.3 | 1.0 | II | e | B |
| *Miliusa velutnia* | Domsal (DOM) | U.P. | 747 | 7.92 | 11.7 | 9.7 | 7.8 | 1.1 | 1.6 | 7.0 | 6.3 | 5.1 | 3.7 | 2.9 | 2.4 | III | — | — |
| *Morus alba* | Mulberry (MUL) | U.P. | 743 | 8.20 | 11.8 | 9.8 | 7.9 | 1.0 | 1.4 | 6.6 | 5.8 | 4.8 | 3.8 | 2.9 | 2.4 | II | — | B |
| *Morus serrata* | Mulberry (MUL) | H.P. | 657 | 7.03 | 10.2 | 8.5 | 6.8 | 0.9 | 1.3 | 5.6 | 5.0 | 4.1 | 2.6 | 2.0 | 1.6 | III | — | B |
| *Morus laevigata* | Bola (BOL) | Andaman | 588 | 8.61 | 12.3 | 10.2 | 8.2 | 1.0 | 1.5 | 7.2 | 6.4 | 5.3 | 3.3 | 2.5 | 2.1 | — | — | B |
| *Ougeinia eejeinensis (Syn. O. delbergioides)* | Sandan (SAD) | M.P. | 784 | 8.54 | 13.3 | 11.1 | 8.9 | 1.2 | 1.7 | 8.5 | 7.5 | 6.2 | 5.1 | 3.9 | 3.2 | I | — | B |
| *Phoebe hainesiana* | Bonsum (BOH) | Assam | 566 | 9.50 | 13.2 | 11.0 | 8.8 | 0.8 | 1.2 | 8.8 | 7.8 | 6.4 | 2.8 | 2.1 | 1.8 | II | c | B |
| *Pinus roxburghii* | Chir (CHR) | U.P. | 525 | 9.82 | 8.5 | 7.3 | 6.0 | 0.6 | 0.9 | 6.0 | 5.3 | 4.4 | 2.0 | 1.5 | 1.3 | III | b | C |

**Table 1** — (*Continued*)

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *(Syn. P. longifolia)* | | | | | | | | | | | | | | | | | | |
| *Pinus wallichiana* | Kail (KAL) | | 515 | 6.80 | 6.6 | 5.6 | 5.0 | 0.6 | 0.8 | 5.2 | 4.6 | 3.8 | 1.7 | 1.3 | 1.0 | II | c | C |
| *Phoebe goalperansis* | Bonsum (BOH) | Assam | 511 | 7.65 | 9.7 | 8.1 | 6.5 | 0.7 | 1.0 | 6.6 | 5.9 | 4.8 | 2.2 | 1.7 | 1.4 | II | c | B |
| *Parretiopsis jacquementiena* | Rohu Parrotia | H.P. | 761 | 5.77 | 12.5 | 10.4 | 8.3 | 1.2 | 1.7 | 6.8 | 6.1 | 5.0 | 4.0 | 3.1 | 2.5 | III | — | B |
| *Pinus kesia (Syn. Pinus insularis)* | Khasi pine (KPI) | North East | 513 | 7.38 | 8.9 | 7.4 | 5.9 | 0.6 | 0.7 | 5.8 | 5.2 | 4.3 | 1.5 | 1.2 | 1.0 | III | a | B |
| *Pistacia integerrima* | Kikar singhi | J&K | 881 | 7.32 | 13.1 | 10.9 | 8.7 | 1.2 | 1.7 | 8.0 | 7.1 | 5.8 | 4.3 | 3.4 | 2.8 | — | — | — |
| *Podocarpus nerrifolius* | Thitmin (THT) | S.Andaman | 533 | 9.41 | 12.5 | 10.4 | 8.3 | 6.1 | 0.9 | 8.0 | 7.1 | 5.8 | 2.6 | 2.0 | 1.6 | II | — | — |
| *Polyalthia fragrances* | Debdaru (DEB) (Nedunar) | Maharashtra | 752 | 9.15 | 11.9 | 9.9 | 7.9 | 0.8 | 1.2 | 6.7 | 6.0 | 4.9 | 3.0 | 2.3 | 1.9 | III | — | B |
| *Polyalthia coreoides* | — | M.P. | 700 | 9.29 | 13.2 | 11.0 | 8.8 | 0.8 | 1.4 | 7.1 | 6.3 | 5.2 | 3.2 | 2.5 | 2.0 | — | — | — |
| *Prunus napeulensis* | Arupati | West Bengal | 548 | 9.41 | 104.4 | 8.7 | 69.6 | 0.8 | 1.2 | 6.7 | 6.0 | 4.9 | 2.4 | 1.9 | 1.6 | — | — | — |
| *Pterespermum acerifolium* | Hattipaila (HAT) | West Bengal | 607 | 9.55 | 13.5 | 11.3 | 9.0 | 0.8 | 1.2 | 8.7 | 7.7 | 6.3 | 3.2 | 2.5 | 2.0 | III | c | B |
| *Qucrcus spp.* | Oak | North East | 657 | 11.65 | 11.4 | 9.5 | 7.6 | 0.8 | 1.2 | 6.7 | 5.9 | 4.8 | 2.0 | 1.6 | 1.3 | II | c | B |
| *Raderomachera xylocarpe (Syn. Sterosperam xylocarpum)* | Vedankonnai | Chennai | 696 | 8.52 | 13.2 | 11.0 | 8.8 | 0.8 | 1.5 | 9.0 | 8.0 | 6.6 | 4.3 | 3.3 | 2.7 | II | a | — |
| *Schleichera oleosa (Syn. S. trijuga)* | Kusum (KUS) | Bihar | 1032 | 12.12 | 15.5 | 13.0 | 10.4 | 0.8 | 2.1 | 10.9 | 9.7 | 7.9 | 6.1 | 4.2 | 3.9 | II | a | A |
| *Schima wallichii* | Chilauni (CHL) | West Bengal | 693 | 9.57 | 11.1 | 9.3 | 7.4 | 0.8 | 1.3 | 6.6 | 5.9 | 4.8 | 2.3 | 1.8 | 1.4 | III | d | B |
| *Shotea assamica* | Makai (MAK) | Assam | 548 | 9.27 | 11.1 | 9.2 | 7.4 | 0.8 | 1.3 | 7.1 | 6.3 | 5.2 | 2.9 | 2.2 | 1.8 | III | c | B |
| *Sonneralia apetale* | Keora (KEO) | West Bengal | 617 | 8.63 | 12.8 | 10.7 | 8.5 | 0.8 | 1.3 | 7.4 | 6.6 | 5.4 | 4.8 | 3.7 | 3.0 | II | — | B |
| *Stereospermum suaveolans* | Padri (PAD) | U.P. | 721 | 8.86 | 13.3 | 11.1 | 8.9 | 0.8 | 1.3 | 7.3 | 7.0 | 5.7 | 3.5 | 2.7 | 2.2 | III | — | B |
| *Tactona grandis* | Teak (TEA) | M.P. | 617 | 8.49 | 12.8 | 10.7 | 8.5 | 0.8 | 1.3 | 7.9 | 7.0 | 5.7 | 4.0 | 3.1 | 2.6 | I | e | B |
| *Terminalia arjuna* | Arjun (ARJ) | Bihar | 794 | 7.71 | 12.2 | 10.2 | 8.2 | 0.8 | 1.6 | 7.4 | 6.6 | 5.4 | 5.2 | 4.1 | 3.3 | II | b | B |
| *Terminalia myriocarpa* | Hollock (HOC) | Assam | 615 | 9.62 | 11.9 | 9.9 | 8.0 | 0.8 | 1.2 | 7.6 | 6.7 | 5.5 | 2.9 | 2.2 | 1.8 | III | a | B |
| *Terminalia procera* | White bombwae (WBO) | N.Andaman | 626 | 8.99 | 11.8 | 9.8 | 7.9 | 0.8 | 1.3 | 7.2 | 6.4 | 5.3 | 3.0 | 2.3 | 1.9 | III | b | B |
| *Taxus buccata* | Yew (YEW) | West Bengal | 705 | 7.79 | 14.3 | 11.9 | 9.5 | 0.8 | 1.7 | 8.7 | 7.8 | 6.4 | 4.7 | 3.7 | 3.0 | — | — | — |
| *Tamarindus indica* | Imli (IML) | Chennai | 913 | 5.63 | 11.4 | 9.5 | 7.6 | 0.8 | 1.7 | 7.0 | 6.2 | 5.1 | 5.3 | 4.1 | 3.4 | — | — | B |
| *Toena ciliata* | Toon (TOO) | U.P. | 487 | 6.40 | 8.7 | 7.3 | 5.8 | 0.8 | 1.0 | 5.4 | 4.8 | 3.9 | 2.4 | 1.8 | 1.5 | II | c | B |
| *Vateria indica* | Vellapine (VEL) | Chennai | 535 | 10.95 | 11.5 | 9.6 | 7.6 | 0.8 | 1.1 | 7.5 | 6.7 | 5.5 | 2.3 | 1.8 | 1.4 | III | e | C |
| *Aeculas indica* | Horse chestnut (HCH) | U.P. | 484 | 7.55 | 8.5 | 7.1 | 5.7 | 0.8 | 1.1 | 4.8 | 4.2 | 3.5 | 1.8 | 1.4 | 1.1 | — | — | B |
| *Borassus flabelsfer* | Tad (Palmyra)(TAD) | A.P. | 838 | 8.79 | 10.5 | 8.8 | 7.0 | 0.8 | 1.0 | 10.0 | 8.8 | 7.2 | 4.7 | 3.6 | 2.7 | — | — | — |
| *Eucalyptus cemaldulensis* | Eucalyptus | Karnataka | 804 | 9.53 | 12.8 | 10.6 | 8.5 | 0.8 | 1.1 | 7.2 | 6.4 | 5.2 | 3.5 | 2.7 | 2.2 | — | — | A |
| *Eucalyptus camaldulenis* | Eucalyptus | U.P. | 781 | 7.03 | 12.4 | 10.4 | 8.3 | 0.8 | 1.6 | 7.9 | 7.0 | 5.7 | 3.5 | 2.8 | 2.3 | — | — | A |
| *Eucalyptus pilularia* | Eucalyptus | T.N. | 713 | 9.22 | 14.8 | 12.3 | 11.1 | 0.8 | 1.4 | 8.5 | 7.6 | 6.2 | 2.8 | 2.2 | 1.8 | — | — | A |
| *Eucalyptus propingus* | Eucalyptus | T.N. | 584 | 7.93 | 12.8 | 10.7 | 8.5 | 0.8 | 1.2 | 8.0 | 5.4 | 4.4 | 2.5 | 1.9 | 1.6 | — | — | A |
| *Eucalyptus saligna* | Eucalyptus | U.P. | 819 | 8.24 | 11.5 | 9.6 | 7.6 | 0.8 | 2.1 | 8.2 | 7.3 | 6.0 | 6.2 | 4.8 | 4.0 | — | — | A |

**Table 1** — (*Concluded*)

[1] Classification for preservation based on durability tests, etc

Class

I — Average life more than 120 months;
II — Average life 60 months and above but less than 120 months; and
III — Average life less than 60 months.

[2] Treatability grades

a — Hearwood easily treatable;
b — Heartwood treatable, but complete penetration not always obtained; in case where the least dimension is more than 60 mm;
c — Heartwood only partially treatable;
d — Heartwood refractory to treatment; and
e — Heartwood very refractory to treatment, penetration of preservative being practically nil even from the ends;

Data based on strength properties at three years of age of tree.

[3] Classifications based on seasoning behaviour of timber and refractoriness with respect to cracking, spliting and drying rate:

A — Highly refractory (slow and difficulty to season free from surface and end cracking);
B — Moderately refractory (may be seasoned free from surface and end cracking within reasonably short periods, given a little protection against rapid drying conditions); and
C — Non-refractory may be rapidly seasoned free from surface and end—cracking even in the open air and sun. If not rapidly dried, they develop blue stain and mould on the surface.

[4] Species thus marked and tested from other localities show higher strength to enable their categorization in higher group.
For Example:

i) Sal tested from West Bengal, Bihar, U.P. and Assam can be classified as Group 'A' species;
ii) Haldu tested from Bihar can be classified as Group 'B' species;
iii) Morus laevigate (Bole) of Assam can be classified in Group 'B' species.

**Table 2 Permissible Lateral Strengths (in Double Shear) of Nails 3.55 mm Diameter, 80 mm Long**
(*Clause* 5.3)

| Sl No. | Species of Wood | | For Permanent Construction Strength per Nail | | For Temporary Structures Strength Per Nail (For Both Lengthening Joints and Node Joints) $\times 10^2$ N |
|---|---|---|---|---|---|
| | Botanical Name | Trade Name | Lengthening Joints $\times 10^2$ N | Node Joints $\times 10^2$ N | |
| (1) | (2) | (3) | (4) | (5) | (6) |
| i) | *Albies pirdrow*[1)] | Fir | 8 | 2 | 12 |
| ii) | *Acacia nilotica* | Babul | 15 | 11 | 34 |
| iii) | *Acrocarpus fraxinifolius* | Mundani | 18 | 9.5 | 19.5 |
| iv) | *Adina cordifolia* | Haldu | 23.5 | 10 | 22 |
| v) | *Albizia lebbeck* | Kokko | 20 | 7 | 24 |
| vi) | *Albizia odoratissima* | Kala Siris | 14 | 5 | 22 |
| vii) | *Anogeissus latifolia* | Axlewood | 20 | 10 | 29 |
| viii) | *Aphanamixis polystachya* | Pitraj | 19 | 9 | 19 |
| ix) | *Calophyllum spp.*[1)] | Poon | 16 | 9 | 21 |
| x) | *Canarium euphyllum* | White dhup | 9 | 8 | 10.5 |
| xi) | *Castanopsis spp.* | Indian chestnut | 18 | 10.5 | 23.5 |
| xii) | *Cedrus deodara*[1)] | Deodar | 9 | 4 | 15 |
| xiii) | *Chukrasia tabularis* | Chikrassy | 24 | 8 | 27 |
| xiv) | *Cinnamomum spp.*[1)] | Cinnomon | 12 | 9 | 13 |
| xv) | *Cupressus torulosa* | Cypress | 6 | 5 | 18 |
| xvi) | *Dipterocarpus macrocarpus* | Hollong | 17 | 7 | 20 |
| xvii) | *Dipterocarpus spp.* | Gurjan | 19 | 9 | 19 |
| xviii) | *Dillenia pertagyna* | Dillenia | 16.5 | 12 | 16 |
| xix) | *Diospyros melanoxylon* | Ebony | 26.5 | 10 | 30.5 |
| xx) | *Eucalyptus eugenioides* | Eucalyptus | 17 | 10 | 30 |
| xxi) | *Grewia tilifolia*[1)] | Dhaman | 13 | 5 | 24 |
| xxii) | *Lagerstroemia spp.* | Jarul | 24.5 | 21.5 | 22.5 |
| xxiii) | *Hopea parviflora* | Hopea | 31.5 | 13 | 28.5 |
| xxiv) | *Lagerstroemia spp.*[1)] | Lendi | 19 | 5 | 26 |
| xxv) | *Mangifera indica* | Mango | 11 | 9 | 16 |
| xxvi) | *Maniltoa polyandra* | Ping | 26 | 23.5 | 32 |
| xxvii) | *Mesua ferrea* | Mesua | 26 | 8 | 41 |
| xxviii) | *Michelia spp.* | Champ | 13 | 9 | 20 |
| xxix) | *Millingtonia spp.*[1)] | 10.5 | 6 | 17 | |
| xxx) | *Morus alba* | Mulberry | 13 | 10.5 | 22.5 |
| xxxi) | *Melia azedarach* | Persian lilac (bakain) | 10.5 | 2.5 | 9 |
| xxxii) | *Ougeinia oojeinensis* | Sandan | 17 | 11 | 18 |
| xxxiii) | *Phoebe spp.*[1)] | Bonsum | 12 | 6 | 13 |
| xxxiv) | *Pinus roxburghii*[1)] | Chir | 11 | 10 | 16 |
| xxxv) | *Pinus wallichiana*[1)] | Kail | 7 | 3 | 9 |
| xxxvi) | *Pterocarpus marsupium* | Bijasal | 15 | 12 | 27 |
| xxxvii) | *Pterocarpus dalbergiodes* | Pauduak | 19 | 14 | 23 |
| xxxviii) | *Planchonia andamanica* | Red bombwe | 14 | 13 | 29 |
| xxxix) | *Quercus spp.* | Oak | 11 | 11 | 27 |
| xl) | *Scheichera cleosa* | Kusum | 23 | 16 | 40 |
| xli) | *Shorea roubusta* | Sal (M.P.) | 23 | 15.5 | 19.5 |
| xlii) | *Shorea robusta* | Sal | 10 | 5 | 19 |
| xliii) | *Stereospenmum* | Padriwood | 16 | 8 | 19.5 |
| xliv) | *Syzygium spp.* | Jamum | 15 | 12 | 25 |
| xlv) | *Tectona grandis* | Teak | 14 | 8 | 13 |
| xlvi) | *Terminalia Bellirica* | Bahera | 10 | 10 | 14 |
| xlvii) | *Terminalia biolata* | White chuglam | 18 | 9 | 21 |
| xlviii) | *Terminalia procera* | Badam | 18 | 10.5 | 20 |
| xlix) | *Terminalia manii*[1)] | Black chuglam | 23 | 10 | 33 |
| l) | *Terminalia myriocarpa* | Hollock | 13 | 10 | 19 |
| li) | *Terminalia alata* | Sain | 16 | 16 | 29 |
| lii) | *Toona spp.* | Toona | 10 | 8 | 21 |
| liii) | *Xylia xylacarpa* | Irul | 23 | 6 | 33 |
| liv) | *Toona ciliata* | Toon | 16 | 9 | 21 |

[1)] Species requiring no preboring for nail penetration.

NOTES

**1** Nails of 3.55 mm diameter are most commonly used. The above values can also be used for 4 mm diameter 100 mm long nails.
**2** The values in N are approximate converted values from kgf. For exact conversion the value is 1 kgf = 9.806 65 N.

**Table 3 Permissible Lateral Strengths (In Double Shear) of Nails 5.00 mm Diameter, 125 mm and 150 mm Long**

(*Clause* 5.3)

| Sl No. | Species of Wood | | For Permanent Construction Strength per Nail | | For Temporary Structures Strength Per Nail (For Both Lengthening Joints and Node Joints) $x10^2$ N |
|---|---|---|---|---|---|
| | Botanical Name | Trade Name | Lengthening Joints x $10^2$ N | Node Joints x $10^2$ N | |
| (1) | (2) | (3) | (4) | (5) | (6) |
| i) | *Abies pindrow*[1)] | Fir | 16.5 | 4.5 | 21 |
| ii) | *Acacia catechu* | Khair | 42 | 25 | 71.5 |
| iii) | *Acacia nilotica*[1)] | Babul | 27 | 13.5 | 53 |
| iv) | *Alibizia procera* | Safed siris | 35 | 18 | – |
| v) | *Alibizia odoratissima*[1)] | Kala siris | 27.5 | 17.5 | 45 |
| vi) | *Alstonia scholaris* | Chatian | 9.5 | 5.5 | 27 |
| vii) | *Anogeissus latifolia* | Axlewood | 22.5 | 13 | 46.5 |
| viii) | *Cupressus torulosa* | Cypress | 20 | 7 | 27 |
| ix) | *Cullenia rosayroana* | Karani | 11 | 9.5 | 30 |
| x) | *Dalbergia sissoo* | Sissoo | 17 | 15 | 43 |
| xi) | *Diptrocarous spp.* | Gurjan | 19.5 | 9.5 | 33 |
| xii) | *Hardwickia binata* | Anjan | 32 | 19 | 59 |
| xiii) | *Hopea perviflora* | Hopea | 60.5 | 25 | 61.5 |
| xiv) | *Holoptelea integrifolia* | kanju | 18 | 12.5 | 37.5 |
| xv) | *Mangifera indica*[1)] | Mango | 22.5 | 15 | 32 |
| xvi) | *Mesua ferrea* | Mesua | 24 | 15.5 | 57.5 |
| xvii) | *Michelia champaca*[1)] | Champ | 26 | 12.5 | 39 |
| xviii) | *Pterocarpus marsupium* | Bijasal | 20.5 | 15 | 43 |
| xix) | *Pinus roxburghii*[1)] | Chir | 9 | 6 | 24 |
| xx) | *Shorea robusta (U.P.)* | Sal | 19.5 | 17 | 37 |
| xxi) | *Shorea robusta* | Sal | 30.5 | 20 | 41 |
| xxii) | *Schleichera cleosa* | Kusum | 15 | 14 | 55 |
| xxiii) | *Stereospimum personatum* | Padriwood | 22 | 8 | 34 |
| xxiv) | *Syzygium cumini* | Jamum | 18 | 14.5 | 38.5 |
| xxv) | *Terminalia myriocarpa* | Hollock | 27.5 | 9 | 41 |
| xxvi) | *Tectona grandis* | Teak | 28 | 13 | 30 |
| xxvii) | *Hopea utilis* | Karung kangoo | 31 | 10 | 58 |
| xxviii) | *Phoebe spp*[1)] | Bonsum | 20 | 7.5 | 30 |

[1)] Species requires no preboring for nail penetration.

NOTES

**1** Nails of 5.00 mm diameter are most commonly used.

**2** The values in N are approximate converted values from kgf. For exact conversion the value is 1 kgf = 9.806 65 N.

**Table 4 Permissible Percentage Moisture Content Values**
(*Clause* 5.4)

| Sl No. | Use | Zones (*see* Notes) | | | |
|---|---|---|---|---|---|
| | | I | II | III | IV |
| (1) | (2) | (3) | (4) | (5) | (6) |
| i) | Structural elements | 12 | 14 | 17 | 20 |
| ii) | Doors and windows: | | | | |
| | a) 50 mm and above in thickness | 10 | 12 | 14 | 16 |
| | b) Thinner than 50 mm | 8 | 10 | 12 | 14 |
| iii) | Flooring strips for general purposes | 8 | 10 | 10 | 12 |
| iv) | Flooring strips for tea gardens | 12 | 12 | 14 | 16 |

NOTES

**1** The country has been broadly divided into the following four zones based on the humidity variations in the country:

a) *Zone I* — Average annual relative humidity less than 40 percent.

b) *Zone II* — Average annual relative humidity 40 to 50 percent.

c) *Zone III* — Average annual relative humidity 50 to 67 percent

d) Zone IV Average annual relative humidity more than 67 percent.

**2** For detailed zonal classification, tolerances, etc, reference may be made to IS 287.

**Table 5 Preferred Cut Sizes of Structural Timbers for Roof Trusses (Span from 3 m to 20 m)**
(*Clause* 5.5.1)

All dimensions in millimetres.

| Sl No. | Thickness | Width | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| i) | 20 | 40 | 50 | 60 | 80 | 100 | — | — | — |
| ii) | 25 | 40 | 50 | 60 | 80 | 100 | 120 | 140 | 160 |
| iii) | 30 | 40 | 50 | 60 | 80 | 100 | 120 | 140 | 160 |
| iv) | 35 | | | 60 | 80 | 100 | 120 | 140 | 160 |
| v) | 40 | | | 60 | 80 | 100 | 120 | 140 | 160 |
| vi) | 50 | | | 60 | 80 | 100 | 120 | 140 | 160 |
| vii) | 60 | | | | 80 | 100 | 120 | 140 | 160 |
| viii) | 80 | | | | | 100 | 120 | 140 | 160 |

NOTES

**1** For truss spans marginally above 20 m, preferred cut sizes of structural timber may be allowed.

**2** Preferred lengths of timber: 1, 1.5, 2, 2.5 and 3 m.

**Table 6 Preferred Cut Sizes of Structural Timber for Roof Purlins, Rafters, Floor Beams, etc**
(*Clause* 5.5.1)

All dimensions in millimetres.

| Sl No. | Thickness | Width | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| i) | 50 | 80 | 100 | 120 | 140 | — | — | — |
| ii) | 60 | 80 | 100 | 120 | 140 | 160 | — | — |
| iii) | 80 | — | 100 | 120 | 140 | 160 | | |
| iv) | 100 | — | — | — | 140 | 160 | 180 | 200 |

NOTE — Preferred lengths of timber: 1.5, 2, 2.5 and 3 m.

**Table 7 Preferred Cut Sizes of Structural Timbers for Partition Framing and Covering, and for Centering**
(*Clause* 5.5.1)

All dimensions in millimetres.

| Sl No. | Thickness | Width | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| i) | 10 | 40 | 50 | 60 | 80 | — | — | — | — | — |
| ii) | 15 | 40 | 50 | 60 | 80 | 100 | — | — | — | — |
| iii) | 20 | 40 | 50 | 60 | 80 | 100 | 120 | 160 | 200 | — |
| iv) | 25 | 40 | 50 | 60 | 80 | 100 | 120 | 160 | 200 | 240 |
| v) | 30 | 40 | 50 | 60 | 80 | 100 | 120 | 160 | 200 | 240 |
| vi) | 40 | 40 | — | 60 | 80 | 100 | 120 | 160 | 200 | 240 |
| vii) | 50 | — | 50 | — | 80 | 100 | 120 | 160 | 200 | 240 |
| viii) | 60 | — | — | 60 | 80 | 100 | 120 | 160 | 200 | 240 |
| ix) | 80 | — | — | — | 80 | 100 | 120 | 160 | 200 | 240 |

NOTE — Preferred lengths of timber: 0.5,1, 1.5, 2, 2.5 and 3 m.

**5.5.2** *Tolerances*

Permissible tolerances in measurements of cut sizes of structural timber shall be as follows:

a) For width and thickness:

1) Up to and including 100 mm : $^{+3}_{-0}$ mm

2) Above 100 mm : $^{+6}_{-3}$ mm

b) For length : $^{+10}_{-0}$ mm

**5.6 Grading of Structural Timber**

**5.6.1** Cut sizes of structural timber shall be graded, after seasoning, into three grades based on permissible defects given in Table 8:

a) Select grade,

b) Grade I, and

c) Grade II.

**5.6.2** The prohibited defects given in **5.6.2.1** and permissible defects given in **5.6.2.2** shall apply to structural timber.

**5.6.2.1** *Prohibited defects*

Loose grains, splits, compression wood in coniferous species, heartwood rot, sap rot, crookedness, worm holes made by powder post beetles and pitch pockets shall not be permitted in all the three grades.

**5.6.2.2** *Permissible defects*

Defects to the extent specified in Table 8 shall be permissible.

NOTE — Wanes are permitted provided they are not combined with knots and the reduction in strength on account of the wanes is not more than the reduction with maximum allowable knots.

**5.6.3** *Location of Defects*

The influence of defects in timber is different for different locations in the structural element. Therefore, these should be placed during construction in such a way so that they do not have any adverse effect on the members, in accordance with Table 8.

**Table 8 Permissible Defects for Cut Sizes of Timber for Structural Use**

(*Clauses* 5.6.1 *and* 5.6.2.2)

All dimensions in millimetres.

| Sl No. | Defects | Select Grade | Grade I | Grade II |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| i) | Wane | Shall be permissible at its deepest portion up to a limit of 1/8 of the width of the surface on which it occurs | Shall be permissible at its deepest portion up to a limit of 1/6 of the width of the surface on which it occurs | Shall be permissible at its deepest portion up to a limit of 1/4 of the width of the surface on which it occurs |
| ii) | Worm holes | Other than those due to powder post beetles are permissible | Other than those due to powder post beetles are permissible | Other than those due to powder post beetles are permissible |
| iii) | Slope of grain | Shall not be more than 1 in 20 | Shall not be more than 1 in 15 | Shall not be more than 1 in 12 |
| iv) | Live knots: | | | |

| *Width of Wide Faces of Cut Sizes of Timber* | *Permissible Maximum Size of Live Knot on* | | *Permissible Maximum Size of Live Knot on* | | *Permissible Maximum Size of Live Knot on* | |
|---|---|---|---|---|---|---|
| *Max* | Narrow Faces and ¼ of the Width Face Close to Edges of Cut Size of Timber | Remaining Central Half of the Width of the Wide Faces | Narrow Faces and ¼ of the Width Face Close to Edges of Cut Size of Timber | Remaining Central Half of the Width of the Wide Faces | Narrow Faces and ¼ of the Width Face Close to Edges of Cut Size of Timber | Remaining Central Half of the Width of the Wide Faces |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 75 | 10 | 10 | 19 | 19 | 29 | 30 |
| 100 | 13 | 13 | 25 | 25 | 38 | 39 |
| 150 | 19 | 19 | 38 | 38 | 57 | 57 |
| 200 | 22 | 25 | 44 | 50 | 66 | 75 |
| 250 | 25 | 29 | 50 | 57 | 66 | 87 |
| 300 | 27 | 38 | 54 | 75 | 81 | 114 |
| 350 | 29 | 41 | 57 | 81 | 87 | 123 |
| 400 | 32 | 44 | 63 | 87 | 96 | 132 |
| 450 | 33 | 47 | 66 | 93 | 99 | 141 |
| 500 | 35 | 50 | 69 | 100 | 105 | 150 |
| 550 | 36 | 52 | 72 | 103 | 108 | 156 |
| 600 | 38 | 53 | 75 | 106 | 114 | 159 |

v) Checks and shakes:

| *Width of the Face of the Timber* | *Permissible Depth* | *Permissible Depth* | *Permissible Depth* |
|---|---|---|---|
| *Max* | *Max* | *Max* | *Max* |
| (1) | (2) | (3) | (4) |
| 75 | 12 | 25 | 36 |
| 100 | 18 | 35 | 54 |
| 150 | 25 | 50 | 75 |
| 200 | 33 | 65 | 99 |
| 250 | 40 | 81 | 120 |
| 300 | 50 | 100 | 150 |
| 350 | 57 | 115 | 171 |
| 400 | 66 | 131 | 198 |
| 450 | 76 | 150 | 225 |
| 500 | 83 | 165 | 249 |
| 550 | 90 | 181 | 270 |
| 600 | 100 | 200 | 300 |

## 5.7 Suitability

**5.7.1** *Suitability in Respect of Durability and Treatability for Permanent Structures*

There are two choices as given in **5.7.1.1** and **5.7.1.2**.

**5.7.1.1** *First choice*

The species shall be any one of the following:

a) Untreated heartwood of high durability. Heartwood, if containing more than 15 percent sap wood, may need chemical treatment for protection;

b) Treated heartwood of moderate and low durability and Class 'a' and Class 'b' treatability;

c) Heartwood of moderate durability and Class 'c' treatability after pressure impregnation; and

d) Sapwood of all classes of durability after thorough treatment with preservative.

**5.7.1.2** *Second choice*

The species of timber shall be heartwood of moderate durability and Class 'd' treatability.

**5.7.2** *Choice of Load-Bearing Temporary Structures* or *Semi-Structural Components at Construction Site*

a) Heartwood of low durability and Class 'e' treatability; or

b) The species whose durability and/or treatability is yet to be established, as listed in Table 1.

### 5.8 Fastenings

All structural members shall be framed, anchored, tied and braced to develop the strength and rigidity necessary for the purposes for which they are used. Allowable stresses or loads on joints and fasteners shall be determined in accordance with recognized principles. Common mechanical fastenings are of bar type such as wire nails and spikes, wood screws and mild steel bolts, and timber connectors including metallic rings or wooden disc-dowels. Chemical fastenings include synthetic adhesives for structural applications.

### 5.9 Requirements of Structural Timber

The various other requirements of structural timber for use in building shall conform to IS 3629.

## 6 PERMISSIBLE STRESSES

**6.1** Fundamental stress values of different groups of timber are determined on small clear specimen according to IS 1708 (Parts 1 to 18). These values are then divided by the appropriate factors of safety to obtain the permissible stresses. In these values, are then applied, appropriate safety factors given in the relevant table of IS 3629 to obtain the permissible stress.

**6.2** The permissible stresses for Groups A, B and C for different locations applicable to Grade I structural timber shall be as given in Table 9 provided that the following conditions are satisfied:

a) Timbers should be of high or moderate durability and be given the suitable treatment, where necessary.

b) Timber of low durability shall be used after proper preservative treatment to IS 401; and

c) Loads should be continuous and permanent and not of impact type.

**6.3** The permissible stresses (excepting $E$) given in Table 9 shall be multiplied by the following factors to obtain the permissible stresses for other grades provided that the conditions laid down in **6.2** are satisfied:

a) For select grade timber : 1.16

b) For Grade II timber : 0.84

**6.3.1** When low durability timbers are to be used [*see* **6.2** (b)] on outside locations, the permissible stresses for all grades of timber, arrived at by **6.2** and **6.3** shall be multiplied by 0.80.

**Table 9 Minimum Permissible Stress Limits (N/mm$^2$) in Three Groups of Structural Timbers (For Grade I Material)**

(*Clauses* 6.2 *and* 6.3)

| Sl No. | Strength Character | Location of Use | Group A | Group B | Group C |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) |
| i) | Bending and tension along grain | Inside[1)] | 18.0 | 12.0 | 8.5 |
| ii) | Shear[2)]: | | | | |
| | a) Horizontal | All locations | 1.05 | 0.64 | 0.49 |
| | b) Along grain | All locations | 1.5 | 0.91 | 0.70 |
| iii) | Compression parallel to grain | Inside[1)] | 11.7 | 7.8 | 4.9 |
| iv) | Compression perpendicular to grain | Inside[1)] | 4.0 | 2.5 | 1.1 |
| v) | Modulus of elasticity, $E$ ($\times 10^3$ N/mm$^2$) | All locations and grade | 12.6 | 9.8 | 5.6 |

[1)] For working stresses for other locations of use, that is, outside and wet, generally factors of 5/6 and 2/3 are applied.

[2)] The values of horizontal shear to be used only for beams. In all other cases shear along grain to be used.

### 6.4 Modification Factors for Permissible Stresses

**6.4.1** *Due to Change in Slope of Grain*

When the timber has not been graded and has major defects like slope of grain, knots and checks or shakes but not beyond permissible value, the permissible stress given in Table 1 shall be multiplied by modification factor $K_1$ for different slopes of grain as given in Table 10.

**6.4.2** *Due to Duration of Load*

For different durations of design load, the permissible stresses given in Table 1 shall be multiplied by the modification factor, $K_2$ given in Table 11.

NOTE — The strength properties of timber under load are time-dependent.

**Table 10 Modifications Factor $K_1$ to Allow for Change in Slope of Grain**
(*Clause* 6.4.1)

| Sl No. | Slope | Modification Factor, $K_1$ | |
|---|---|---|---|
| | | Strength of Beams, Joists and Ties | Strength of Posts or Columns |
| (1) | (2) | (3) | (4) |
| i) | 1 in 10 | 0.80 | 0.74 |
| ii) | 1 in 12 | 0.90 | 0.82 |
| iii) | 1 in 14 | 0.98 | 0.87 |
| iv) | 1 in 15 and flatter | 1.00 | 1.00 |

NOTE — For intermediary slopes of grains, values of modification factor may be obtained by interpolation.

**Table 11 Modifications Factor $K_2$, for Change in Duration of Loading**
(*Clause* 6.4.2)

| Sl No. | Duration of Loading | Modification Factor, $K_2$ |
|---|---|---|
| (1) | (2) | (3) |
| i) | Continuous (Normal) | 1.0 |
| ii) | Two months | 1.15 |
| iii) | Seven days | 1.25 |
| iv) | Wind and earthquake | 1.33 |
| v) | Instantaneous or impact | 2.00 |

**6.4.2.1** The factor $K_2$ is applicable to modulus of elasticity, when used to design timber columns, otherwise they do not apply thereto.

**6.4.2.2** If there are several duration of loads (in addition to the continuous) to be considered, the modification factor shall be based on the shortest duration load in the combination, that is, the one yielding the largest increase in the permissible stresses, provided the designed section is found adequate for a combination of other larger duration loads.

[*Explanation*: In any structural timber design for dead loads, snow loads and wind or earthquake forces, members may be designed on the basis of total of stresses due to dead, snow and wind loads using $K_2$ = 1.33, factor for the permissible stress (of Table 1) to accommodate the wind load, that is, the shortest of duration and giving the largest increase in the permissible stresses. The section thus found is checked to meet the requirements based on dead loads alone with modification $K_2$ = 1.00].

**6.4.2.3** Modification factor, $K_2$ shall also be applied to allowable loads for mechanical fasteners in design of joints, when the wood and not the strength of metal determines the load capacity.

## 7 DESIGN CONSIDERATIONS

**7.1** All structural members, assemblies or framework in a building, in combination with the floors, walls and other structural parts of the building shall be capable of sustaining, with due stability and stiffness the whole dead and imposed loadings as per IS 875 (Parts 1 to 5), without exceeding the limits of relevant stresses specified in this section.

**7.2** The worst combination and location of loads shall be considered for designs. Wind and seismic forces shall not be considered to act simultaneously.

**7.3** The design requirements may be satisfied either by calculations/verification using laws of mechanics or by prototype testing.

**7.3.1** Buildings shall be designed for all dead and imposed loads or forces assumed to come upon them during construction or use, including uplifts or horizontal forces from wind and forces from earthquakes or other loadings. Structural members and their connections shall be proportioned to provide a sound and stable structure with adequate strength and stiffness. Wooden components in construction generally include panels for sheathing and diaphragms, siding, beams, girder, columns, light framings, masonry wall and joist construction, heavy-frames, glued laminated structural members, structural sandwiches, prefabricated panels, lamella arches, portal frames and other auxiliary constructions.

### 7.4 Net Section

**7.4.1** The net section is obtained by deducting from the gross sectional area of timber the projected area of all material removed by boring, grooving or other means at critical plane. In case of nailing, the area of the prebored hole shall not be taken into account for this purpose.

**7.4.2** The net section used in calculating load carrying capacity of a member shall be at least net section determined as above by passing an imaginary plane or a series of connected planes transversely through the members.

**7.4.3** Notches shall in no case remove more than one quarter of the section.

**7.4.4** In the design of an intermediate or a long column, gross section shall be used in calculating load carrying capacity of the column.

### 7.5 Flexural Members

**7.5.1** Such structural members shall be investigated for the following:

a) Bending strength,

b) Maximum horizontal shear,

c) Stress at the bearings, and

d) Deflection.

**7.5.2** *Effective Span*

The effective span of beams and other flexural members shall be taken as the distance from face of supports plus one-half of the required length of bearing at each end except that for continuous beams and joists the span may be measured from centre of bearing at those supports over which the beam is continuous.

**7.5.3** Usual formula for flexural strength shall apply in design:

$$f_{ab} = \frac{M}{Z} \leq f_b$$

**7.5.4** *Form Factors for Flexural Members*

The following form factors shall be applied to the bending stress:

a) *Rectangular section* — For rectangular sections, for different depths of beams, the form factor $K_3$ shall be taken as:

$$K_3 = 0.81 \left[ \frac{D^2 + 89\,400}{D^2 + 55\,000} \right]$$

NOTE — Form factor ($K_3$) shall not be applied for beams having depth less than or equal to 300 mm.

b) *Box beams and I-beams* – For box beams and I-beams the form factor, $K_4$ shall be obtained by using the formula:

$$K_4 = 0.8 + 0.8\,y \left[ \frac{D^2 + 89\,400}{D^2 + 55\,000} - 1 \right]$$

where

$$y = p_1^2 (6 - 8\,p_1 + 3\,p_1^2)\,(1 - q_1) + q_1$$

c) *Solid circular cross-sections* — For solid circular cross-sections the form factor, $K_5$ shall be taken as 1.18.

d) *Square cross-sections* — For square cross-sections where the load is in the direction of diagonal, the form factor, $K_6$ shall be taken as 1.414.

**7.5.5** *Width*

The minimum width of the beam or any flexural member shall not be less than 50 mm or 1/50 of the span, whichever is greater.

**7.5.6** *Depth*

The depth of beam or any flexural member shall not be taken more than three times of its width without lateral stiffening.

**7.5.6.1** *Stiffening*

All flexural members having a depth exceeding three times its width or a span exceeding 50 times its width or both shall be laterally restrained from twisting or buckling and the distance between such restraints shall not exceed 50 times its width.

**7.5.7** *Shear*

**7.5.7.1** The following formulae shall apply:

a) The maximum horizontal shear, when the load on a beam moves from the support towards the centre of the span, and the load is at a distance of three to four times the depth of the beam from the support, shall be calculated from the following general formula:

$$H = \frac{VQ}{Ib}$$

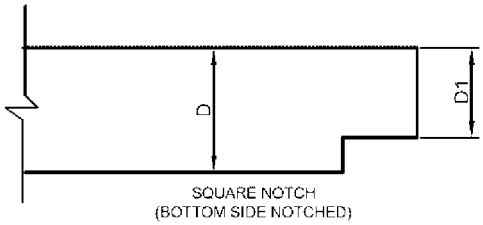
b) For rectangular beams:

$$H = \frac{3\,V}{2\,bD}$$

c) For notched beams, with tension notch at supports (*see* **7.5.7.3**):

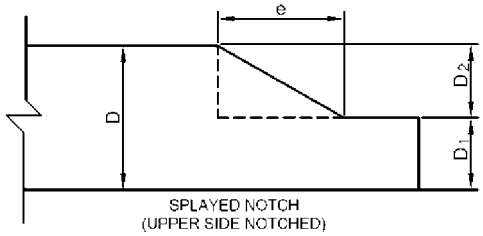
$$H = \frac{3\,VD}{2\,bD_1^{\,2}}$$

d) For notched at upper (compression) face, where $e > D$:




$$H = \frac{3V}{2bD_1}$$

e) For notched at upper (compression) face, where $e < D$:



$$H = \frac{3V}{2b\left[D - \left\{\frac{D_2}{D}\right\}e\right]}$$

**7.5.7.2** For concentrated loads:

$$V = \frac{10C\,(l-x)(x/D)^2}{9l\left[2+(x/D)^2\right]}$$

and for uniformly distributed loads,

$$V = \frac{W}{2}\left(1 - \frac{2D}{l}\right)$$

After arriving at the value of $V$, its value will be substituted in the for mula:

$$H = \frac{VQ}{Ib}$$

**7.5.7.3** In determining the vertical reaction $V$, the following deductions in loads may be made:

a) Consideration shall be given to the possible distribution of load to adjacent parallel beams, if any;

b) All uniformly distributed loads within a distance equal to the depth of the beam from the edge of the nearest support may be neglected except in case of beam hanging downwards from a particular support; and

c) All concentrated loads in the vicinity of the supports may be reduced by the reduction factor applicable according to Table 12.

**Table 12 Reduction Factor for Concentrated Loads in the Vicinity of Supports**

[*Clause* 7.5.7.3 (c)]

| Distance of Load from the Nearest Support | 1.5 D or Less | 2 D | 2.5 D | 3 D or More |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| Reduction factor | 0.60 | 0.40 | 0.20 | No reduction |

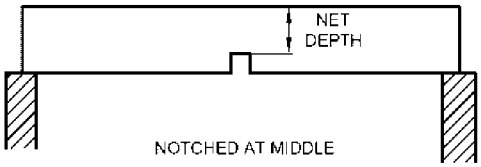
NOTE — For intermediate distances, factor may be obtained by linear interpolation.

**7.5.7.4** Unless the local stress is calculated and found to be within the permissible stress, flexural member shall not be cut, notched or bored except as follows:

a) Notches may be cut in the top or bottom neither deeper than one-fifth of the depth of the beam nor farther from the edge of the support than one-sixth of the span;

b) Holes not larger in diameter than one quarter of the depth may be bored in the middle third of the depth and length, and

c) If holes or notches occur at a distance greater than three times the depth of the member from the edge of the nearest support, the net remaining depth shall be used in determining the bending strength.




NOTCHED BEAMS

**7.5.8** *Bearing*

**7.5.8.1** The ends of flexural members shall be supported in recesses which provide adequate ventilation to prevent dry rot and shall not be enclosed. Flexural members except roof timbers which are supported directly on masonry or concrete shall have a length of bearing of not less than 75 mm. Members supported on corbels, offsets and roof timbers on a wall shall bear immediately on and be fixed to wall-plate not less than 75 mm × 40 mm.

**7.5.8.2** Timber joists or floor planks shall not be supported on the top flange of steel beams unless the bearing stress, calculated on the net bearing as shaped to fit the beam, is less than the permissible compressive stress perpendicular to the grain.

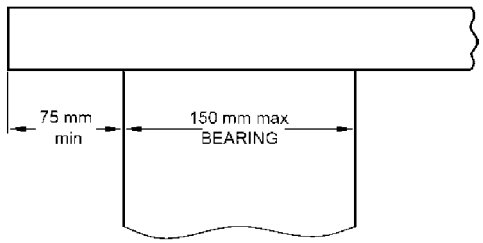
**7.5.8.3** *Bearing stress*

**7.5.8.3.1** *Length and position of bearing*

a) At any bearing on the side grain of timber, the permissible stress in compression perpendicular to the grain, $f_{cn}$, is dependent on the length and position of the bearing.

b) The permissible stresses given in Table 1 for compression perpendicular to the grain are also the permissible stresses for any length at the ends of a member and for bearings 150 mm or more in length at any other position.

c) For bearings less than 150 mm in length located 75 mm or more from the end of a member as shown in the figure below, the permissible stress may be multiplied by the modification factor, $K_7$ given in Table 13.




d) No allowance need be made for the difference in intensity of the bearing stress due to bending of a beam.

e) The bearing area should be calculated as the net area after allowance for the amount of wane.

f) For bearings stress under a washer or a small plate, the same coefficient specified in Table 13 may be taken for a bearing with a length equal to the diameter of the washer or the width of the small plate.

g) When the direction of stress is at angle to the direction of the grain in any structural member, then the permissible bearing stress in that member shall be calculated by the following formula:

$$f_c\theta = \frac{f_{cp} \times f_{cn}}{f_{cp} \sin^2 \grave{e} + f_{cn} \cos^2 \grave{e}}$$

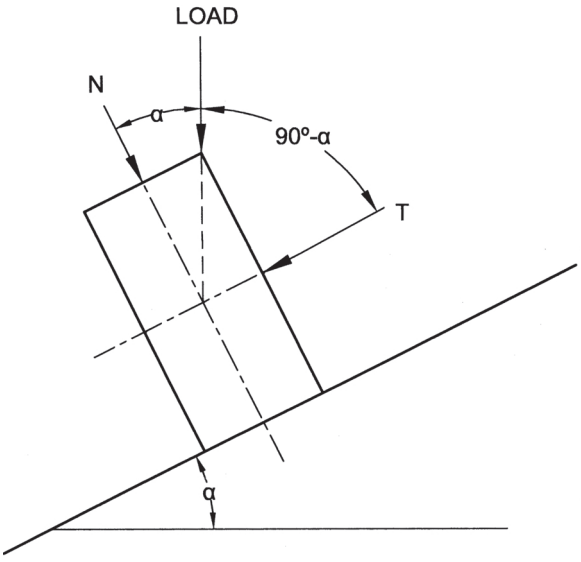
**Table 13 Modification Factor $K_7$ for Bearing Stresses**

[*Clauses* 7.5.8.3.1 (c) and (f)]

| Length of Bearing mm | 15 | 25 | 40 | 50 | 75 | 100 | 150 or More |
|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Modification factor, $K_7$ | 1.67 | 1.40 | 1.25 | 1.20 | 1.13 | 1.10 | 1.00 |

**7.5.9.5** *Purlin*

Purlin is a structural member, essentially a beam subjected to transverse loads and rests on the top chord of roof truss. Being under bi-axial bending, vertical loads are resolved into two components that is, perpendicular to and parallel to roof slopes (*see* Fig. below). The effect of normal and tangential components of the vertical load is worked out separately and the in-fibre stress in bending, will be the algebraic sum of both.




**7.5.9.6** *Deflection*

The deflection in the case of all flexural members supporting brittle materials like gypsum ceilings, *slates*, tiles and asbestos sheets shall not exceed 1/360 of the span. The deflection in the case of other flexural members shall not exceed 1/240 of the span and 1/150 of the freely hanging length in the case of cantilevers.

**7.5.9.6.1** Usual formula for deflection shall apply*:*

$$\delta = \frac{KWL^3}{EI}$$ (ignoring deflection due to shear strain)

*K*-values = 1/3 for cantilevers with load at free end,

= 1/8 for cantilevers with uniformly distributed load,

= 1/48 for beams supported at both ends with point load at centre, and

= 5/384 for beams supported at both ends with uniformly distributed load.

**7.5.9.6.2** In order to allow the effect of long duration loading on *E*, for checking deflection in case of beams and joists the effective loads shall be twice the dead load, if timber is initially dry.

**7.5.9.6.3** Self weight of beam shall be considered in design.

**7.6 Columns**

NOTE — The formulae given are for columns with pin end conditions and the length shall be modified suitably with other end conditions.

**7.6.1** *Solid Columns*

Solid columns shall be classified into short, intermediate and long columns depending upon their slenderness ratio (*S*/*d*) as follows:

a) *Short columns* — where *S*/*d* does not exceed 11.

b) *Intermediate columns* — where *S*/*d* is between 11 and $K_8$.

c) *Long columns* — where *S*/*d* is greater than $K_8$.

**7.6.1.1** For short columns, the permissible compressive stress shall be calculated as follows:

$$f_c = f_{cp}$$

**7.6.1.2** For intermediate columns, the permissible compressive stress is calculated by using the following formula:

$$f_c = f_{cp}\left[1 - \frac{1}{3}\left(\frac{S}{K_8 d}\right)^4\right]$$

**7.6.1.3** For long columns, the permissible compressive stress shall be calculated by using the following formula:

$$f_c = \frac{0.329E}{\left(S/d\right)^2}$$

**7.6.1.4** In case of solid columns of timber, $S/d$ ratio shall not exceed 50.

**7.6.1.5** The permissible load on a column of circular cross-section shall not exceed that permitted for a square column of an equivalent cross-sectional area, where side of square is equal to 0.886 times the diameter.

**7.6.1.6** For determining $S/d$ ratio of a tapered column such as for wooden poles, its least dimension shall be taken as the sum of the corresponding least dimensions at the small end of the column and one-third of the difference between this least dimension at the small end and the corresponding least dimension at the large end, but in no case shall the least dimension for the column be taken as more than one and a half times the least dimension at the small end. The induced stress at the small end of the tapered column shall not exceed the permissible compressive stress in the direction of grain.

**7.6.2** *Built-up Columns*

**7.6.2.1** *Box column*

Box columns shall be classified into short, intermediate and long columns as follows:

a) *Short columns* — where $\frac{S}{\sqrt{d_1^2 + d_2^2}}$ is less than 8;

b) *Intermediate columns* — where $\frac{S}{\sqrt{d_1^2 + d_2^2}}$ is between 8 and $K_9$; and

c) *Long columns* — where $\frac{S}{\sqrt{d_1^2 + d_2^2}}$ is greater than $K_9$.

**7.6.2.2** For short columns, the permissible compressive stress shall be calculated as follows:

$$f_c = qf_{cp}$$

**7.6.2.3** For intermediate columns, the permissible compressive stress shall be obtained using the following formula:

$$f_c = qf_{cp}\left[1 - \frac{1}{3}\left(\frac{S}{K_9\sqrt{d_1^2 + d_2^2}}\right)^4\right]$$

**7.6.2.4** For long columns, the permissible compressive stress shall be calculated by using the following formula:

$$f_c = \frac{0.329UE}{\left(\frac{S}{\sqrt{d_1^2 + d_2^2}}\right)^2}$$

**7.6.2.5** The following values of $U$ and $q$, depending upon plank thickness ($t$) in **7.6.2.3** and **7.6.2.4**, shall be used:

| $t$ | $U$ | $q$ |
|---|---|---|
| mm | | |
| 25 | 0.80 | 1.00 |
| 50 | 0.60 | 1.00 |

**7.6.3** *Spaced Columns*

**7.6.3.1** The formulae for solid columns as specified in **7.6.1** are applicable to spaced columns with a restraint factor of 2.5 or 3, depending upon distances of end connectors in the column.

NOTE — A restrained factor of 2.5 for location of centroid group of fasteners at $S/20$ from end and 3 for location at $S/10$ to $S/20$ from end shall be taken.

**7.6.3.2** For intermediate spaced column, the permissible compressive stress shall be:

$$f_c = f_{cp}\left[1 - \frac{1}{3}\left(\frac{S}{K_{10}d}\right)^4\right]$$

**7.6.3.3** For long spaced columns, the formula shall be:

$$f_c = \frac{0.329E \times 2.5}{(S/d)^2}$$

**7.6.3.4** For individual members of spaced columns, $S/d$ shall not exceed 80.

**7.6.4** Compression members shall not be notched. When it is necessary to pass services through such a member, this shall be effected by means of a bored hole provided that the local stress is calculated and found to be within the permissible stress specified. The distance from the edge of the hole to the edge of the member shall not be less than one quarter of width of the face.

**7.7 Structural Members Subject to Bending and Axial Stresses**

**7.7.1** Structural members subjected both to bending and axial compression shall be designed to comply with the following formula:

$$\frac{f_{ac}}{f_c} + \frac{f_{ab}}{f_b} \text{ is not greater than 1.}$$

**7.7.2** Structural members subjected both to bending and axial tension shall be designed to comply with the

following formula:

$$\frac{f_{at}}{f_t} + \frac{f_{ab}}{f_b} \text{ is not greater than 1.}$$

**7.8 Tension Member (Ties)**

The stress is axial tension parallel to grain of wood and shall be calculated on the basis of net-section area which shall not exceed the safe permissible value in tension parallel to grain which is expressed as:

$$f_{at} = \frac{\text{Maximum for force prevailing}}{\text{Area of cross-section}} \leq f_t$$

**7.9 Timber Roof Truss**

Trusses are framed structures in which separate straight members are so arranged and connected at their ends that members form triangles. The external loads cause direct stresses in the members. Essentially, a plane structure is one which is very stiff in the plane of the members but very flexible in every other direction. For members subjected to reversal of stresses, design has to be for one stress and tested for the other applied at the panel points. Eccentricity of meeting members at joint may result in the increased stresses in design.

# ANNEX A

(*Clause* 2)

## LIST OF REFERRED INDIAN STANDARDS

| *IS No.* | *Title* |
|---|---|
| 287 : 1993 | Permissible moisture content for timber used for different purposes — Recommendations (*third revision*) |
| 401 : 2001 | Preservation of timber — Code of practice (*fourth revision*) |
| 707 : 2011 | Glossary of terms applicable to timber technology and utilization (*third revision*) |
| 875 | Code of practice for design loads (other than earthquake) for buildings and structures |
| (Part 1) : 1987 | Dead loads — Unit weights of building material and stored materials (*second revision*) |
| (Part 2) : 1987 | Imposed loads (*second revision*) |
| (Part 3) : 2015 | Wind loads (*third revision*) |
| (Part 4) : 1987 | Snow loads (*second revision*) |
| (Part 5) : 1987 | Special and load combinations (*second revision*) |
| 1708 (Parts 1 to 18) : 1986 | Methods of testing small clear specimens of timber (*second revision)* |
| 2366 : 1983 | Code of practice for nail-jointed timber construction (*first revision)* |
| 2911 (Part 2) : 1980 | Code of practice for design and construction of pile foundations: Part 2 Timber piles (*first revision*) |
| 3629 : 1986 | Specification for structural timber in building (*first revision*) |
| 4891 : 1988 | Specification for preferred cut sizes of structural timber (*first revision*) |
| 4970 : 1973 | Key for identification of commercial timbers (*first revision)* |
| 11096 : 1984 | Code of practice for design construction of bolt-jointed construction |

# ANNEX B

(*Foreword*)

## COMMITTEE COMPOSITION

Building Construction Practices Sectional Committee, CED 13

| *Organization* | *Representative(s)* |
|---|---|
| In Personal Capacity (*Flat No 2061, Engineers Apts, Plot 11, Sector 18A, Dwarka, New Delhi 110078*) | Shri D. S. Sachdev (***Chairman***) |
| Ahluwalia Contracts (India) Limited, New Delhi | Shri Shobhit Uppal<br>Shri Pradeep Kumar (*Alternate*) |
| All India Glass Manufacturers' Association, New Delhi | Shri Sourabh Kankar<br>Shri Rupinder Shelly (*Alternate*) |
| Association of Consulting Civil Engineers (India), Bangalore | Shri A. N. Prakash<br>Shri Satish V. Salpekar (*Alternate*) |
| Bhabha Atomic Research Centre, Mumbai | Shri K. Srinivas<br>Shri H. E. Iyer (*Alternate*) |
| Building Materials and Technology Promotion Council, New Delhi | Shri J. K. Prasad<br>Shri S. K. Gupta (*Alternate*) |
| CSIR-Central Building Research Institute, Roorkee | Dr S. G. Dave<br>Dr R. K. Garg (*Alternate*) |
| CSIR-North East Institute of Science and Technology, Jorhat | Dr S. D. Baruah<br>Shri Amitava Biswas (*Alternate*) |
| CSIR-Structural Engineering Research Centre, Chennai | Dr Nagesh R. Iyer<br>Dr P. Srinivasan (*Alternate*) |
| Central Public Works Department, CDO Unit, New Delhi | Chief Engineer (CSQ)<br>Superintending Engineer (D) II (*Alternate*) |
| Confederation of Construction Products and Services, New Delhi | Shri Deepak Gahlowt<br>Shri Shashi Kant (*Alternate*) |
| Delhi Development Authority, New Delhi | Chief Engineer (SWZ)<br>Superintending Engineer (P) (SWZ) (*Alternate*) |
| Engineers India Limited, New Delhi | Shri Rajanji Srivastava<br>Shri Ravindra Kumar (*Alternate*) |
| Forest Research Institute, Dehradun | Dr V. S. Kishan Kumar |
| Housing and Urban Development Construction Corporation, New Delhi | Shri Akhilesh Kumar<br>Shrimati Manju Safaya (*Alternate*) |
| Indian Buildings Congress, New Delhi | Shri S. C. Bhatia<br>Shri P. S. Chadha (*Alternate*) |
| Indian Pest Control Association, New Delhi | Shri Ravi Vyas<br>Shri Udayan Ghosh (*Alternate*) |
| Indian Plywood Industries Research and Training Institute, Bangalore | Shri Jagadish Vengala<br>Shri Amitava Sil (*Alternate*) |
| Larsen and Toubro Limited, ECC Division, Chennai | Shri Rajan Venkateswaan<br>Shri V. Sukumar Hebbar (*Alternate*) |
| Military Engineer Services, Engineer-in-Chief's Branch, Army Headquarters, New Delhi | Ms Mala Mohan<br>Shrimati Shobhana V. (*Alternate*) |
| National Buildings Construction Corporation, New Delhi | Shri Rakesh Marya<br>Shri V. K. Sharma (*Alternate*) |
| NTPC Ltd, New Delhi | Shri R. L. Das<br>Shri Anil Kapoor (*Alternate*) |
| Pest Control (India) Pvt Ltd, Mumbai | Shri Shankar M. Ghuge<br>Shri Sanjay Kumar Mishra (*Alternate*) |
| Public Works Department, Govt of NCT of Delhi, New Delhi | Shri A. K. Sinha<br>Shri Puneet Kumar Vats (*Alternate*) |

| *Organization* | *Representative(s)* |
|---|---|
| Research, Designs and Standards Organization, (Ministry of Railways), Lucknow | Director (Works)<br>Shri Ashutosh Kumar (*Alternate*) |
| School of Planning and Architecture, New Delhi | Dr Anil Dewan<br>Prof Jaya Kumar (*Alternate*) |
| The Indian Institute of Architects, Mumbai | Shri Vijay Garg<br>Shri Shamit Manchanda (*Alternate*) |
| The Institution of Engineers (India), Kolkata | Shri P. K. Adlakha<br>Shri Devendra Gill (*Alternate*) |
| In personal capacity (*Pratap Nursery Lane, Panditwari, Dehradun 248 007*) | Shri K. S. Pruthi |
| BIS Directorate General | Shri B. K. Sinha, Scientist E and Head (Civil Engg) [Representing Director General (*Ex-officio*)] |

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Scientist 'D' (CED), BIS

## Panel for Timber, CED 13/P-3

| | |
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| Forest Research Institute, Dehradun | Dr V. S. Kishan Kumar |
| Indian Plywood Industries Research & Training Institute, Bangalore | Shri Jagadish Vengala<br>Shri Amitava Sil (*Alternate*) |
| Confederation of Construction Products and Services, New Delhi | Shri Shashi Kant |

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**Amendments Issued Since Publication**

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